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Washington, DC 20375-5320

Information Technology Division Technical Paper Abstracts 1998

JANET L. STROUP

Navy Center for Applied Research in Artificial Intelligence
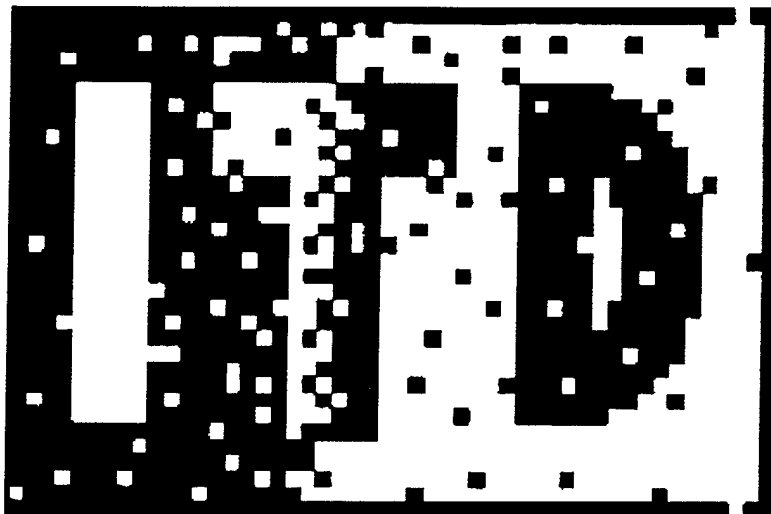*Information Technology Division*

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This report provides abstracts for technical publications produced during 1998 by personnel of the Information Technology Division (ITD), one of the largest research and development collectives at the Naval Research Laboratory (NRL). The abstracts are organized into sections that represent the six branches within ITD: the Navy Center for Applied Research in Artificial Intelligence, Communication Systems, the Center for High Assurance Computer Systems, Transmission Technology, Advanced Information Technology, and the Center for Computational Science. Within each section, a list of branch papers published in 1997 has been included; abstracts for these papers may be found in prior-year editions of this report. Information on obtaining a copy of one or more of the abstracted or listed publications is also provided.

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T his report provides abstracts for technical publications produced by ITD personnel during 1998. The abstracts are organized into sections by the ITD branch. Within each section, a list of papers published in 1997, given ITD report number, title, and author(s), has also been included; abstracts for these papers may be found in prior-year editions of this report.

T o obtain a copy of one or more of the abstracted or listed papers, contact the NCARAI Library at 202-767-0018 (telephone); 202-767-3172 (fax); library@aic.nrl.navy.mil (email); or by postal mail at

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>Washington, DC 20375-5337

P lease give the report number, title, and author(s) of each paper desired. Additionally, some of the papers produced by NCARAI are available through anonymous FTP to host <ftp.aic.nrl.navy.mil>, in the /pub/papers directory.

Introduction

The Naval Research Laboratory (NRL) is the corporate laboratory for the United States Navy, and employs more than 3,700 civilians to conduct research and development programs in a wide range of technical disciplines. While more than 750 of NRL's employees hold doctorates, all members of the research staff participate extensively in national and international technical groups. In order to inform the research, academic and industrial communities of its research activities, NRL annually publishes in excess of 1,000 journal articles, technical papers and reports.

The Information Technology Division (ITD) is one of the largest research and development collectives at NRL. ITD employs more than 220 civilian researchers organized into six branches: the Navy Center for Applied Research in Artificial Intelligence, Communication Systems, the Center for High Assurance Computer Systems, Transmission Technology, Advanced Information Technology, and the Center for Computational Science. The technical areas of expertise in ITD include:

Communications

network simulation
HF communications
communication security
communications networking

Human-Computer Interaction

visualization techniques
metrics and evaluation
speech communications
human-computer dialogue

Artificial Intelligence

intelligent simulation
adaptive control software
machine learning methods
robotic vision and control
interactive systems
intelligent decision aids
reasoning under uncertainty

Software

computer security
network security
software assurance
software specification methods
hard real time computing
adaptive software testing
information security

Decision Support Systems

parallel processing techniques
prototyping techniques
distributed decision support
distributed simulation
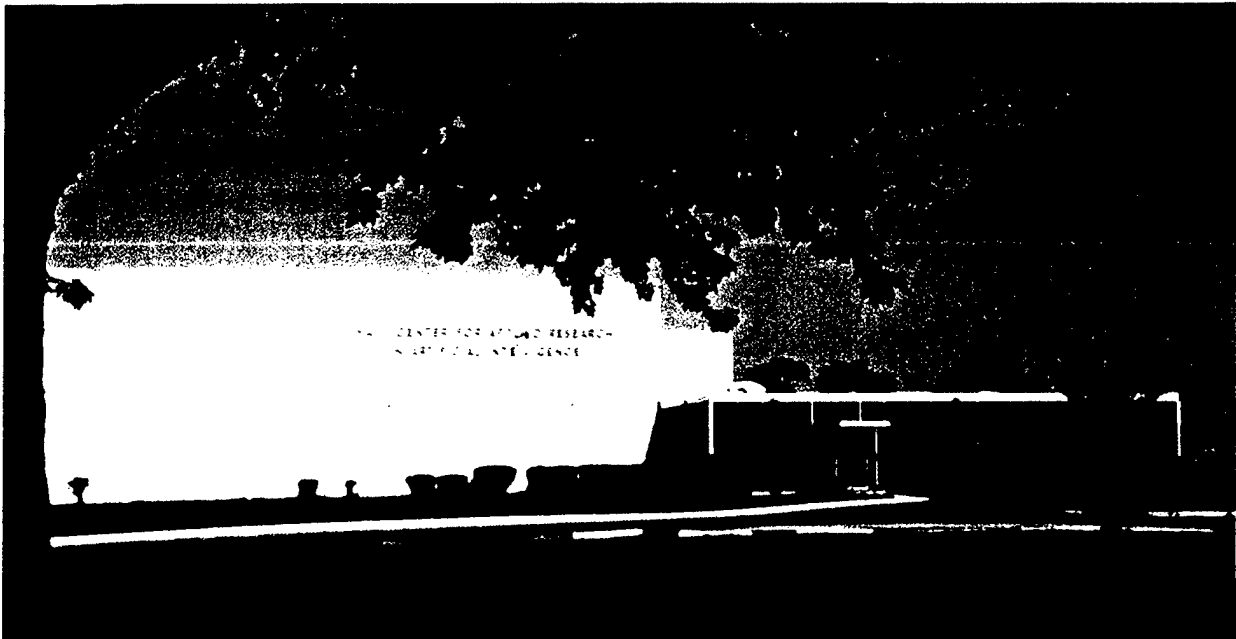
The Navy Center for Applied Research in Artificial Intelligence (NCARAI) is engaged in research efforts designed to address the application of artificial intelligence (AI) technology and techniques critical to Navy and national concerns. The emphasis at NCARAI is the linkage of theory and application in demonstration projects that use a full spectrum of AI methods.

The technical papers and reports generated by the NCARAI document the accomplishments of projects in computational reasoning for intelligent decision aids, intelligent M4 (multi-media, multi-modal) systems, interface design and evaluation, machine learning, and sensor-based systems. Innovative basic and exploratory research in these areas are made possible by NCARAI's staff, an impressive cross section of AI talent from the Government civilian and military sectors, visiting scholars from the academic communities, and consulting scientists from various industries. An ongoing seminar series, featuring notable scientists and scholars from around the country and abroad, provides an excellent forum to exchange information and maintain awareness of current developments.

Intelligent M4 Systems
Code 5512

Title: Communicating with a Semi-Autonomous Robot
Author(s): Dennis Perzanowski, William Adams and Alan C. Schultz
E-mail Address: dennisp@aic.nrl.navy.mil, adams@aic.nrl.navy.mil,
schultz@aic.nrl.navy.mil
Citation: Working Notes of the AAAI 1998 Spring Symposium on Integrating
Robotic Research: Taking the Next Leap, Stanford, CA: Stanford University,
55-59.
Date: 23-25 March 1998
Report No.: AIC-98-015

Abstract
The Intelligent Multimodal Multimedia and the Adaptive Systems Groups at the
Navy Center for Applied Research in Artificial Intelligence have been investigating a
natural language and gesture interface to a mobile robot. Our interface utilizes
robust natural language understanding and resolves some of the ambiguities in
natural language by means of gesture input. The natural language and gestural
information is integrated with knowledge of a particular environment and
appropriate robotic responses are produced. So-called "deictic" elements or objects
(e.g. "this chair," "that table," "him" or "her") and directional elements (e.g. "over
there," "my left" and "your right") when parsed by a natural language system can
be comprehensible, but mean nothing if the utterance is unaccompanied by
gesture. A command such as "Go/Move over there" is ambiguous without an
appropriate gesture to indicate some place in the environment to which to move.
Moreover, a command such as "Turn left fifteen degrees" can be confusing if an
inappropriate or contradictory gesture is perceived. This interface handles both
natural language ambiguity and appropriate or inappropriate (contradictory)
gestures.

Title: Creating Natural Language Interfaces to VR Systems: Experiences,
Observations and Lessons Learned
Author(s): Stephanie S. Everett, Kenneth Wauchope and Manuel A. Pérez-
Quiñones
E-mail Address: everett@aic.nrl.navy.mil, wauchope@aic.nrl.navy.mil
Citation: Future Fusion: Application Realities for the Virtual Age, Proceedings of 4th
International Conference on Virtual Systems and Multimedia (VSMM98), Vol. 2,
Gifu, Japan: IOS Press, 469-474.
Date: 18-20 November 1998
Report No.: Not assigned

Abstract
This paper discusses two research projects that explore some of the capabilities of
spoken natural language interfaces to virtual reality (VR) systems. Both projects
use commercial speech recognition and synthesis technology combined with in-
house command interpreters that interface to the VR applications. Details about

the interpreters and the technical approaches are provided, along with a discussion of some of the questions and issues raised by the projects, including information representation in VR models, use of the visual context to establish the interaction context, and difficulties in referencing events in the VR world.

Title: Integrating Natural Language and Gesture in a Robotics Domain
Author(s): Dennis Perzanowski, Alan C. Schultz and William Adams
E-mail Address: dennisp@aic.nrl.navy.mil, schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil
Citation: Proceedings of the IEEE International Symposium on Intelligent Control: ISIC/CIRA/ISAS Joint Conference, Gaithersburg, MD: National Institute of Standards and Technology, 247-252.
Date: 14-17 September 1998
Report No.: AIC-98-013

Abstract

Human-computer interfaces facilitate communication, assist in the exchange of information, process commands and controls, among many additional interactions. For our work in the robotics domain, we have concentrated on integrating spoken natural language and natural gesture for command and control of a semi-autonomous mobile robot. We have assumed that both spoken natural language and natural gesture are more user-friendly means of interacting with a mobile robot, and from the human standpoint, such interactions are easier, given that the human is not required to learn additional interactions, but can rely on "natural" ways of communication. So-called "synthetic" methods, such as data gloves, require additional learning; however, this is not the case with natural language and natural gesture. We, therefore, rely on what is natural to both spoken language when it is used in conjunction with natural gestures for giving commands. Furthermore, we have been integrating these interactions with the robotics components as the robotics system is being developed. The interface is not treated as an ad hoc add-on or patch. By doing so, we believe the interface will be more robust and because it is being integrated during system development, we hope to achieve a more seamless interface, one which both acts and feels as an integral part of the robotics application. In this paper, we will discuss the kinds of interactions which our system is currently capable of performing. We will also discuss the processing of the various input to produce an appropriate robotic response. And finally, we will discuss what future kinds of interactions we would like to incorporate into the system, and what will be required to achieve these results.

Title: Mental Representations of Spatial Language
Author(s): Geoffrey S. Hubona, Stephanie Everett, Elaine Marsh and Kenneth Wauchope
E-mail: everett@aic.nrl.navy.mil, marsh@aic.nrl.navy.mil, wauchope@aic.nrl.navy.mil
Citation: International Journal of Human-Computer Studies **48**, no. 6: 705-728.
Date: June 1998
Report No.: Not assigned

Abstract

Previous studies have provided evidence of multi-level mental representations of language-conveyed spatial (scenic) information. However, the available evidence is

largely inconclusive with regard to the structure of these mental representations. A laboratory experiment assesses computer-assisted problem-solving performance abilities when language-conveyed representations of spatial information are matched with the language perspective of the task and with individual cognitive skills. Our findings largely validate this paradigm of îcognitive fitî that has been applied in non-language computer display domains, and the results suggest language-fostered "perspective-bias" in the formation and use of mental representations of spatial (scenic) information.

Title: So What's So 'Human' About Human Language?
Author(s): Dennis Perzanowski
E-mail Address: dennisp@aic.nrl.navy.mil
Citation: Presentation at the 43rd Annual Conference, International Linguistics
   Association, New York, NY.
Date: 17-19 April 1998
Report No.: AIC-98-014

Abstract
So-called "deictic" elements or objects (e.g. "this chair," "that table," "him" or "her") and directional elements (e.g. "over there," "my left" and "your right") when parsed by a natural language system can be interpreted by that system, but in the real world will signify nothing if the utterance is unaccompanied by some kind of gesture. A command such as "Go/Move over there" is ambiguous without an appropriate gesture to indicate some place in the environment to which to move. Moreover, a command such as "Turn left fifteen degrees" can be confusing if an inappropriate or contradictory gesture is perceived. We have been implementing a natural language and gestural interface to a semi-autonomous robot. Our purpose has been to construct a human-robot interface that facilitates communication between human and machine. However, our research raises interesting questions concerning what is appropriate for any communicative act to occur, be the participants of that event human or robot.

Title: 'To Boldly Go' ... To the Next Level of Human/Robot Interaction
Author(s): Dennis Perzanowski
E-mail Address: dennisp@aic.nrl.navy.mil
Citation: Working Notes of the AAAI 1998 Spring Symposium on Integrating
   Robotic Research: Taking the Next Leap, Stanford, CA: Stanford University,
   157-158.
Date: 23-25 March 1998
Report No.: AIC-98-016

Abstract
If the next leap in robotics research comes about through the integration of work in such areas as machine vision, navigation, manipulation, etc., improved expressive power will be required for human-computer interfaces to these robotic systems. Only then will human-computer interaction be able to exploit the capabilities of integrated robotic systems.

Title: Animation as Documentation: A Replication with Reinterpretation
Author(s): A.W. Lipps, J.G. Trafton and W.D. Gray
E-mail Address: trafton@itd.nrl.navy.mil
Citation: Proceedings of the 45th Annual Society for Technical Communications
    Conference, Anaheim, CA: STC, 199-201.
Date: 17-20 May 1998
Report No.: Not assigned

Abstract
Animated demonstrations are replacing text as the vehicle for documentation, help, and training on new software systems. An animated demonstration is a demonstration of a particular feature or features by a ghost user. The demonstration executes the procedure for performing a task, on-screen, as the user passively watches. Whereas research into the effectiveness of animated demonstrations has produced mixed results, certain patterns of behavior are emerging. The current study replicates the learning advantage offered by animated demonstration and shows that retention is equal to that of a group instructed by text after a one week retention interval. Implications for development of on-line training materials are discussed.

Title: Computational Modeling of Multimodal I/O in Simulated Cockpits
Author(s): James A. Ballas
E-Mail Address: ballas@itd.nrl.navy.mil
Citation: Proceedings of the Third Annual Symposium on Situational Awareness in
    the Tactical Air Environment, Naval Air Warfare Center, Patuxent River, MD:
    NAWCAD.
Date: 2-3 June 1998
Report No.: Not assigned

Abstract
The purpose of this research is to investigate the use of computational models of human performance to design and evaluate information displays in military cockpits. The focus of the current work is using computational modeling to evaluate auditory interfaces. The approach includes four steps: 1) develop auditory interface designs; 2) augment a computational model called Executive-Process/Interactive Control (EPIC) to incorporate the human performance effects of these interface designs; 3) collect human performance data; and 4) evaluate the accuracy of the model against the empirical data. Work at NRL includes development of interface designs and collection of human performance data. The EPIC modeling is being done by David Kieras and David Meyer at the University of Michigan.

This research is based upon previous work at NRL on the design of adaptive automation interfaces. Ballas, Heitmeyer and Perez (1992) found that certain interface features mitigated a transient automation deficit effect. This deficit is evidenced with longer reaction times on the first few responses upon resuming a task that has been previously automated. The effect is short-lived, and has not been found in studies that examine average performance over several minutes.

Ballas et al. used a low fidelity cockpit simulation with two tasks: tracking and tactical assessment. Kieras and Meyer successfully modeled human performance of both tasks in the '92 study, including automation deficit effects. Their detailed model generated an explanation for this deficit: upon resuming the task, subjects randomly scan the tactical assessment task and handle objects in a random order. Usually subjects know about he developing pattern in the task and handle objects in a preferred order, producing shorter reaction times.

This explanation from the EPIC model suggested that the effect would not occur if subjects began the task with a low level of demand. Empirical results confirmed this prediction. The EPIC model also suggests that a sound cue which directs eye movement to the appropriate object in the interface will reduce the deficit. An interface which uses spatialized sound has been developed to assess this prediction. The 3-D sound will represent the relative horizontal position of the object that should be handled. Preliminary results provided support for this prediction.

Finally, the EPIC model of this multiple task simulation assumes that the tracking task is momentarily suspended when the eyes move into the other task, as well as when the choice response on the other task is executed. To evaluate this assumption, tracking holds are being analyzed. An increase in the holds is observed when responses are made to the other task.

Altogether, these results suggest that computational modeling can be a very useful method of evaluating cockpit interfaces in the early phases of engineering design.

Title: Exploration in the Experiment Space: The Relationship between Systematicity and Performance
Author(s): S.B. Trickett, J.G. Trafton and P.D. Raymond
E-mail Address: trafton@itd.nrl.navy.mil
Citation: Proceedings of the Twentieth Annual Conference of the Cognitive Science Society, Mahwah, NJ: Lawrence Erlbaum Associates, 1067-1072.
Date: 1998
Report No.: Not assigned

Abstract
Much of the research on scientific reasoning has investigated the use of explicit, hypothesis-testing strategies. However, there is evidence that scientific reasoning problems can be solved by exploration of the experiment space. This study investigates the strategies by which people explore the experiment space and examines the relationship between the systematicity of this search and successful performance.

Title: Factors Affecting Difficulty of Generate and Test in Algebra Problem Solving
Author(s): A.W. Lipps, I.R. Katz and J.G. Trafton
E-mail Address: trafton@itd.nrl.navy.mil
Citation: Presentation at the Virginia Academy of Science, Richmond, VA.
Date: 1998
Report No.: Not assigned

Abstract
Generate-and-test strategy, sometimes called "guess and check," is being included in algebra and pre-algebra curricula, but the component skills have not been included in standardized assessments of mathematical skill or addressed thoroughly in empirical research of mathematical reasoning. The current research seeks to further understanding of how students use generate-and-test and how particular problem features affect problem difficulty. We hypothesized that, for problems with multiple correct answers, the percentage of correct solutions within all possible solutions affects the problem difficulty. To test this, we manipulated the percentage of correct solutions for six problems. Each problem was instantiated in a base (unchanged) version, and two manipulated versions that resulted in relatively greater or lesser percentages of correct solutions. Thirty-nine undergraduates solved two problems of each version. Results showed that reducing the percentage of correct solutions made the problems significantly harder than the base version. Additionally there was marginal evidence that the presence of an additional constraint (the mechanism for manipulating the solution percentage) made the problem harder.

Title: The Hobbes Software Architecture for Virtual Environment Interface Development
Author(s): Kapil R. Dandekar, James Templeman, Robert Page and Linda Sibert
E-mail Address: templeman@itd.nrl.navy.mil, page@itd.nrl.navy.mil, sibert@itd.nrl.navy.mil
Citation: NRL Formal Report NRL/FR/5510-98-9876, Washington, DC: Naval Research Laboratory.
Date: 16 April 1998
Report No.: Not assigned

Abstract
This report describes the design and utilization of the Hobbes system. This system is a framework for rapid interface development for high performance graphics and virtual reality (VR) applications. The design of the system incorporates the following fundamental features: object-oriented design, transparency of the underlying windowing system and graphics application program interface (API), transparency of multiprocessing and shared memory systems, and portability and extendibility. The system also supports the following capabilities: creation of real-time three-dimensional (3-D) graphics applications; simultaneous, independent use of multiple I/O devices (not limited to mouse and keyboard); and transparent, high throughput use of local or networked I/O devices. The reader will acquire an appreciation of the benefits of the Hobbes system as a tool for both development and research, particularly concerning applications that require rapid prototyping of novel human-computer interaction (HCI) techniques. The reader will also gain an understanding for how the Hobbes system architecture could evolve to include the functionality of a general virtual environment (VE) testbed. The current C++

implementation of the Hobbes system runs on Silicon Graphics workstations and makes extensive use of the Performer application development environment.

Title: Human Speaker Recognition (NIRDAL System)
Author(s): Astrid Schmidt-Nielsen and Thomas H. Crystal
E-Mail Address: schmidtn@itd.nrl.navy.mil
Citation: Presentation at the National Institute of Standards and Technology Speaker Recognition Workshop, College Park, MD.
Date: 31 March - 1 April 1998
Report No.: Not assigned

There is no abstract for this presentation.

Title: Human vs. Machine Speaker Identification with Telephone Speech
Authors: Astrid Schmidt-Nielsen and Thomas H. Crystal
E-mail Address: schmidtn@itd.nrl.navy.mil
Citation: Proceedings of the Fifth International Conference on Spoken Language Processing (ICSLP'98), Paper Number 0148, Sydney, Australia: Australian Speech and Technology Association, 221-225.
Date: 30 November - 4 December 1998
Report No.: Not assigned

Abstract
An experiment was conducted to compare the speaker recognition performance of human listeners to that of computer algorithms/systems using 3-second samples of speech taken from telephone conversations. The listener tests were designed to parallel the 1998 algorithm evaluation run by the U.S. National Institute of Standards and Technology, using telephone conversation speech. When the test samples were from the same telephone number as the training speech, listener panels were about as good as the best algorithm, and the humans were better than typical algorithms. On the whole, humans were more robust to degradation than the algorithms. For test samples from different handsets/telephone numbers than the training speech, human performance degraded somewhat, but humans clearly outperformed algorithms.

Title: ISART: Interactive Situation Assessment and Rollup Tool
Author(s): James Ballas and S. Kushnier
E-Mail Address: ballas@itd.nrl.navy.mil
Citation: H. R. Arabnia and D. Zhu (eds.), Proceedings of the International Conference on Multisource-Multisensor Information Fusion (FUSION98), Las Vegas, NV: CSREA Press.
Date: 6-9 July 1998
Report No.: Not assigned

Abstract
A research program at NRL and NAWCAD has been investigating and developing interface software to support collaboration between an experienced user and a AI based software system for situation assessment. A prototype called ISART has been developed which implements an approach to collaborative situation assessment between human and computer. This prototype provides user interface,

knowledge base, and inference support for the user to insert situation assessments into a computer system at several levels of abstraction. The system represents these abstractions in a knowledge base and on the screen, and can reason about and make recommendations for tactical action. Two interface capabilities are unique in ISART: Intelligent Aggregation and Mission Widgets. The first lets the user roll up units into forces. The second lets the user generate and manipulate graphic mission representations.

Title: Interruption of Human Decision Makers During Human-Computer Interaction
Author(s): Daniel C. McFarlane
E-Mail Address: mcfarlane@itd.nrl.navy.mil
Citation: Presentation at Leveraging Intelligent and Emerging Technology to Support 21st Century Leaders (IET-21), National Defense University, Fort Lesley J. McNair, Washington, DC.
Date: 23 July 1998
Report No.: Not assigned

This report has no abstract.

Title: Modern Computational Perspectives on Executive Mental Control: Where to from Here?
Author(s): D. E. Kieras, D. E. Meyer, James A. Ballas, and E. J. Lauber
E-Mail Address: ballas@itd.nrl.navy.mil
Citation: Presentation at Attention and Performance XVIII, Cumberland Lodge, Windsor Great Park, England.
Date: 13-17 July 1998
Report No.: Not assigned

Abstract
Future research on cognitive control must precisely characterize the supervisory functions of executive mental processes. The achievement of this objective will be facilitated by formal concepts and algorithms from contemporary computer operating systems. In particular, operating-system fundamentals can help to advance work with the Executive-Process Interactive Control (EPIC) architecture, a theoretical framework for computational modeling of human multiple-task performance. EPIC models that incorporate general executive processes like those of operating systems provide insights about how people schedule tasks, allocate perceptual-motor resources, and coordinate task processes during multiple-task performance under both laboratory and real-world conditions. Such insights may lead to discoveries about the acquisition of procedural task knowledge and efficient multitasking skills.

Title: Perceptual Relevance of Objectively Measured Descriptors for Speaker Characterization

Author(s): Burhan F. Necioglu, Mark A. Clements, Thomas P. Barnwell and Astrid Schmidt-Nielsen

E-Mail Address: schmidtn@itd.nrl.navy.mil

Abstract
Subjective testing of speaker recognizability is an intricate, time consuming and very expensive process, but using objectively measurable descriptors to augment the subjective speaker recognizability tests could result in increased efficiency and reliability. This paper describes our investigation into the relevancy of a set of objective descriptors to human perception of speaker identity through multidimensional scaling (MDS) of subjective speaker pair similarity judgments. The evaluated objective descriptors can achieve same/different detection error rates as low as 4.13% for male speaker pairs, and 8.17% for female speaker pairs, with only 3 seconds of speech. Five descriptors related to glottal, vocal tract and prosodic features were found to have significant correlations with the perceptual dimensions of the MDS solutions.

Title: Role of Solution Space in Generating Example Problems
Author(s): A.W. Lipps, I.R. Katz and J.G. Trafton
E-mail Address: trafton@itd.nrl.navy.mil

Abstract
What factors affect students' use of generate-and-test in solving algebra word problems? We hypothesized that, for problems with multiple correct answers, percentage of correct solutions within all possible solutions affects problem difficulty. Six problems were each instantiated in three versions: unchanged, relatively greater and relatively lesser percentages of correct solutions. Reducing the percentage of correct solutions made problems with non-uniform correct solution distributions significantly harder than the base version.

Title: Virtual Knowledge: Uncertainty Relations and Military Waste Management
Author(s): William F. Lawless, James A. Ballas, T. Castelao and C. P. Abubucker
E-Mail Address: lawless@itd.nrl.navy.mil, ballas@itd.nrl.navy.mil

Abstract
Dynamic behavior is enacted from static information that corresponds interdependently to observation as observations of past actions guide new ones on

the fly. Interdependence is broken when experience is reconstructed through concepts, producing mutually exclusive categories between action and observation. This dualism between conjugate information variables generates incommensurable world views between two groups which restrict the internal or external measurement of their social dynamics while giving rise to social dissonance that naturally occurs across a group to enable acculturation to its practices, and between groups to enable social change. However, change leads to oral accounts that have been classified as spurious. The change being real and the knowledge inaccessible, we classify the latter as virtual knowledge. We have exploited this effect in a complex social setting to improve the management of military nuclear wastes. The implications and a path forward are discussed.

Intelligent Systems
Code 5515

Title: An Algorithm to Find Minimal Sound and Complete Partitions for Model Checking
Author(s): Diana Gordon
E-mail Address: gordon@aic.nrl.navy.mil

Abstract
The objective of this research is to reduce the computational complexity of model checking by using abstraction. Our goal is to fully automate the process of finding abstractions. The type of abstraction of interest here is partitioning of variable values. This report presents a method that builds on the work of Clarke, Grumberg, and Long (1994). The method presented here consists of an algorithm that, when coupled with the algorithm of Clarke et al., completely automates the selection of a partition that is sound, complete, and in a certain respect minimal.

Title: Case-Based Reasoning Integrations
Author(s): David W. Aha and Jody J. Daniels
E-mail Address: aha@aic.nrl.navy.mil

This report has no abstract.

Title: Comparing Simplification Procedures for Decision Trees on an Economics Classification Task

Author(s): David W. Aha and Leonard A. Breslow
E-mail Address: aha@aic.nrl.navy.mil, breslow@aic.nrl.navy.mil

Abstract
Several commercial case-based reasoning (CBR) shells now use decision trees to index cases, including ReMind (Cognitive Systems, Inc.), Kate (AckronSoft), and The Easy Reasoner (The Haley Enterprise). These trees serve to expediate case retrieval and to generate comprehensible explanations of case retrieval behavior. Unfortunately, induced trees are often large and complex, reducing their explanatory power. To combat this problem, some commercial systems contain an option for simplifying decision trees. However, while many methods for simplifying decision trees exist, they have not been systematically compared and must have not been applied to case retrieval. This report builds on our previous survey and initial empirical comparison of tree simplification procedures. In this report, we compare them on a specific, challenging task that is the focus of an existing CBR effort. We examine which tree simplication procedures are useful for this task and suggest which ones should be included in a commercial CBR tool.

Title: A Compression Algorithm for Probability Transition Matrices

Author(s): William Spears
E-mail Address: spears@aic.nrl.navy.mil

Abstract
This paper describes a compression algorithm for probability transition matrices. The compressed matrix is itself a probability transition matrix. In general the compression is not error-free, but the error appears to be small even for high levels of compression.

Title: Continuous Localization Using Evidence Grids

Author(s): Alan Schultz and William Adams
E-Mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil

Abstract
Evidence grids provide a uniform representation for fusing temporally and spatially distinct sensor readings. However, the use of evidence grids requires that the robot be localized within its environment. Odometry errors typically accumulate over time, making localization estimates degrade, and introducing significant errors into evidence grids as they are built. We have addressed this problem by developing a

method for "continuous localization", in which the robot corrects its localization estimates incrementally and on the fly. Assuming the mobile robot has a map of its environment represented as an evidence grid, localization is achieved by building a series of "local perception grids" based on localized sensor readings and the current odometry, and then registering the local and global grids. The registration produces an offset which is used to correct the odometry. Results are given on the effectiveness of this method, and quantify the improvement of continuous localization over dead reckoning. We also compare different techniques for matching evidence grids and for searching registration offsets.

Title: Correcting for Length Biasing in Conversational Case Scoring
Author(s): David W. Aha and Leonard A. Breslow
E-mail Address: aha@aic.nrl.navy.mil, breslow@aic.nrl.navy.mil
Citation: Internal Report.
Date: 1998
Report No.: AIC-98-007

Abstract

Inference's conversational case-based reasoning (CCBR) approach, embedded in the CBR Content Navigator line of products, is susceptible to a bias in its case scoring algorithm. In particular, shorter cases tend to be given higher scores, assuming all other factors are held constant. This report summarizes our investigation for mediating this bias. We introduce an approach for eliminating this bias and evaluate how it affects retrieval performance for six case libraries. We also suggest explanations for these results, and note the limitations of our study.

Title: Description and Functionality of HTE (Version 2.90)
Author(s): H. Munoz-Avila, Leonard A. Breslow, David W. Aha and D. Nau
E-mail Address: munoz@aic.nrl.navy.mil, breslow@aic.nrl.navy.mil,
 aha@aic.nrl.navy.mil
Citation: Internal Report.
Date: 1998
Report No.: AIC-98-022

Abstract

This document describes HTE (Hierarchical Task Editor), an interactive tool designed to help the military commander to keep track of all tasks that, according to military doctrine, need to be performed when executing a NEO (Noncombatant Evacuation Operation). Currently, the tool represents 194 tasks described by the Joint Publication 3-07.5 "Joint Tactics, Techniques and Procedures for Noncombatant Evacuation Operations," published on the 30th of September 1997, in the form of a hierarchical task-decomposition network. HTE also represents the hierarchical organization of the JTF (Joint Task Force) and correspondences between JTF elements and the tasks.

Title: Dining with GAs: Operator Lunch Theorems
Author(s): William Spears and Kenneth DeJong
E-mail Address: spears@aic.nrl.navy.mil, dejong@aic.nrl.navy.mil
Citation: Wolfgang Banzhaf and Colin Reeves (eds.), Foundations of Genetic
    Algorithms, vol. 5, San Francisco, CA: Morgan Kaufmann.
Date: 1998
Report No.: Not assigned

Abstract

There has been considerable discussion of the pros/cons of
recombination and mutation operators in the context of Holland's
schema theory. In this paper we define a common framework for
extending and relating previous "disruption" and "construction"
analyses for both recombination and mutation. This results in several
insights into the properties of recombination and
mutation, including a No Free Lunch theorem for recombination
operators as well as the lack of such a theorem for mutation.

Title: Error-Correcting Output Codes for Local Learners
Author(s): Francesco Ricci and David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: Proceedings of the Tenth European Conference on Machine Learning,
    Chemnitz, Germany: Springer, 280-291.
Date: 1998
Report No.: AIC-98-001

Abstract

Error-correcting output codes (ECOCs) represent classes with a set of output bits,
where each bit encodes a binary classification task corresponding to a unique
partition of the classes. Algorithms that use ECOCs learn the function
corresponding to each bit, and combine them to generate class predictions. ECOCs
can reduce both variance and bias errors for multiclass classification tasks when the
errors made at the output bits are not correlated. They work well with algorithms
that eagerly induce global classifiers (e.g., C4.5) but do not assist simple local
classifiers (e.g., nearest neighbor), which yield correlated predictions across the
output bits. We show that the output bit predictions of local learners can be
decorrelated by selecting different features for each bit. We present promising
empirical results for this combination of ECOCs, nearest neighbor, and feature
selection.

Title: Exploration and Spatial Learning Research at NCARAI
Author(s): Brian Yamauchi, Alan Schultz, William Adams and Kevin Graves
E-mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil
Citation: Proceedings of the Conference on Automated Learning and Discovery,
    Workshop W7: Robot Exploration and Learning, Pittsburgh: CMU.
Date: 11-13 June 1998
Report No.: AIC-98-019

This report has no abstract.

Title: Feature Weighting for Lazy Learning Algorithms
Author(s): David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: H. Liu and H. Motoda (eds.), Feature Extraction, Construction and
  Selection: A Data Mining Perspective, Norwell, MA: Kluwer, 13-32.
Date: 1998
Report No.: AIC-98-003

Abstract

Learning algorithms differ in the degree to which they process their inputs prior to
their use in performance tasks. Many algorithms eagerly compile input samples
and use only the compilations to make decisions. Others are lazy: they perform
less precompilation and use the input samples to guide decision making. The
performance of many lazy learners significantly degrades when samples are
defined by features containing little or misleading information. Distinguishing
feature relevance is a critical issue for these algorithms, and many solutions have
been developed that assign weights to features. This chapter introduces a
categorization framework for feature weighting approaches used in lazy similarity
learners and briefly surveys some examples in each category.

Title: Frontier-Based Exploration Using Multiple Robots
Author(s): B. Yamauchi
E-Mail Address:
Citation: Proceedings of the Second International Conference on Autonomous
Agents (Agents '98), Minneapolis, MN: ACM Press, 47-53.
Date: May 1998
Report No.: Not assigned

Abstract

Frontier-based exploration directs mobile robots to regions on the boundary
between unexplored space and space that is known to be open. Previously, we
have demonstrated that frontier-based exploration can be used to map indoor
environments where walls and obstacles may be in arbitrary orientations. In this
paper, we show how frontier-based exploration can be extended to multiple robots.
In our approach, robots share perceptual information, but maintain separate global
maps, and make independent decisions about where to explore. This approach
enables robots to make use of information from other robots to explore more
effectively, but it also allows the team to be robust to the loss of individual robots.
We have implemented our multirobot exploration system on real robots, and we
demonstrate that they can explore and map office environments as a team.

Title: Genome Length as an Evolutionary Self-adaptation

Author(s): Connie L. Ramsey, Kenneth A. De Jong, John J. Grefenstette, Annie S. Wu and Donald S. Burke

E-mail Address: ramsey@aic.nrl.navy.mil, dejong@aic.nrl.navy.mil, aswu@aic.nrl.navy.mil

Citation: Agoston E. Eiben, Thomas Baeck, Marc Schoenauer and Hans-Paul Schwefel (eds.), Proceedings of the 5th International Conference on Parallel Problem Solving from Nature, Amsterdam, The Netherlands: Springer-Verlag, 345-353.

Date: 27-30 September 1998

Report No.: Not assigned

Abstract

There is increasing interest in evolutionary algorithms that have variable-length genomes and/or location independent genes. However, our understanding of such algorithms both theoretically and empirically is much less well developed than the more traditional fixed-length, fixed-location ones. Recent studies with VIV (VIrtual Virus), a variable length, GA-based computational model of viral evolution, have revealed several emergent phenomena of both biological and computational interest. One interesting and somewhat surprising result is that the length of individuals in the population self-adapts in response to the mutation rate applied, so the GA adaptively strikes the balance it needs to successfully solve the problem. Over a broad range of mutation rates, genome length tends to increase dramatically in the early phases of evolution, and then decrease to a level based on the mutation rate. The plateau genome length (i.e., the average length of individuals in the final population) generally increases in response to an increase in the base mutation rate. Furthermore, the mutation operator rate and adapted length resulting in the best problem solving performance is about one mutation per individual. This is also the rate at which mutation generally occurs in biological systems, suggesting an optimal, or at least biologically plausible, balance of these operator rates. These results suggest that an important property of these algorithms is a considerable degree of self-adaptation.

Title: Identification of Distant Insignia in a Visual Database

Author(s): Behzad Kamgar-Parsi, T.C. Zenner, Behrooz Kamgar-Parsi, J.C. Sciortino and A. Khan

E-Mail Address: behzad@ait.nrl.navy.mil, kamgar@aic.nrl.navy.mil

Citation: Proceedings of the International Society for Optical Engineering (SPIE) Conference on ATR, Vol. 3371, Orlando, FL: SPIE, 346-353.

Date: April 1998

Report No.: Not assigned

Abstract

Searching a large visual database for the item(s) most similar to a test object is a tedious task that has many applications. This task is further complicated if the test object (extracted from an image) is degraded by its distance and other factors. A distant target is typically subject to blurring, noise, and other distortions, so that when it is matched to database items it may turn out to be less similar to its own ideal model than another database item. To reduce the likelihood of such misidentifications, we propose an approach where the database is enlarged to include appropriately degraded versions of the ideal items in the original database. The extracted target is likely to match closely one of the distorted versions of its

corresponding database item. In particular we discuss the problem of ship identification from the smokestack insignia, i.e., extracting the ship's insignia from its color photo and finding its closest matches in a database containing thousands of registered shipping line insignias. This is a problem of interest to international regulatory agencies, insurance companies and others. We discuss how the database insignias, as well as the extracted insignias, are processed and indexed, and how the distorted versions of ideal insignias are generated.

Abstract

Monitoring surface ship traffic is a problem of considerable interest to the Navy, international regulatory agencies, insurance companies, and others. This problem is being pursued in different ways, such as radar signature identification, smokestack insignia recognition, superstructure shape identification, etc., by different Navy organizations, including NRL. A joint effort by the Information Technology and the Tactical Electronic Warfare Divisions of NRL has resulted in considerable progress in solving the challenging problem of smokestack insignia identification. The problem requires finding the best match to the encountered insignia in the database of registered shipping line insignias, and deciding whether the match is correct. The database of registered insignias, despite its huge size (several thousand items), is incomplete. The problem is further complicated if the extracted insignia (from an image background) is degraded by its distance and other factors, as well as the existence of discrepancies among individual insignias representing the same shipping line. A distant target is typically subject to blurring, noise, and other distortions, so that when it is matched to database items it may turn out to be less similar to its own ideal model than another database item. In this paper, we describe the approaches we have developed for dealing with distant insignias to reduce the likelihood of misidentifications, as well as processing and indexing the insignias. We note that searching through a large database of almost similar items is an extremely tedious task for a human operator and requires at least some level of automation. The techniques developed here are suitable for building a fully automated system, as well as a decision-aid to facilitate and enhance the performance of the operator.

Title: Integrating Exploration, Localization, and Navigation
Author(s): Brian Yamauchi, Alan Schultz and William Adams
E-mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil
Citation: Working Notes of the AAAI 1998 Spring Symposium on Integrating Robotic Research: Taking the Next Leap, Stanford, CA: Stanford University, 105-107.
Date: 23-25 March 1998
Report No.: AIC-98-017

Abstract

Recent advances in robotics research have resulted in effective techniques allowing mobile robots to explore and map unknown environments, maintain accurate estimates of their position at all times, and navigate adaptively in dynamic environments. This paper describes our research on combining these capabilities into an integrated mobile robot system. Frontier-based exploration enables mobile robots to explore unknown environments by navigating to regions on the boundary between space that is known to be open and unknown space. Continuous localization allows robots to maintain an accurate position estimate by comparing recent perceptions to a map representing the structure of the environment. We have integrated frontier-based exploration with continuous localization in ARIEL, a mobile robot system capable of exploring unknown environments while remaining localized. We present quantitative results from a series of experimental trials using a real robot in an indoor office environment. We also describe plans for integrating ARIEL with Trulla, a path planner that generates vector fields for navigation that are free of local minima and can adapt quickly to changes in dynamic environments.

Title: Integrating Map Learning, Localization and Planning in a Mobile Robot
Author(s): Brian Yamauchi, Alan Schultz, William Adams and Kevin Graves
E-mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil
Citation: Proceedings of the 1998 IEEE International Symposium on Computational Intelligence in Robotic and Automation, Gaithersburg, MD: IEEE, 331-336.
Date: September 1998
Report No.: AIC-98-020

Abstract

The major themes of our research include the creation of mobile robot systems that are robust and adaptive in rapidly changing environments and the view of integration as a basic research issue. Where reasonable, we try to use the same representation to allow different components to work more readily together and to allow better and more natural integration of and communication between these components. In this paper, we summarize our recent work in integrated mobile robot exploration, localization, navigation, and planning.

Title: MAGELLAN: An Integrated Adaptive Architecture for Mobile Robotics

Author(s): Brian Yamauchi, Pat Langley, Alan C. Schultz, John Grefenstette and William Adams

E-mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil

Citation: Internal Report.

Date: 1998

Report No.: AIC-98-021

Abstract

In this paper we describe MAGELLAN, an integrated architecture for mobile robotics. The system represents its spatial knowledge in terms of a topological network that connects a set of distinct places, each represented by evidence grids that contain probabilistic descriptions of occupancy. MAGELLAN includes a module for place recognition that determines its initial location and when it has reached a goal, a module for continuous localization that maintains accurate estimates of the robot's position, and a module for navigation that generates path plans and executes them using reactive behaviors. Experiments in two laboratories with different characteristics suggest that the system can operate robustly across a range of environments, including ones that involve dynamic changes.

Title: Matching Algorithms to Problems: An Experimental Test of the Particle Swarm and Some Genetic Algorithms on the Multimodal Problem Generator

Author(s): J. Kennedy and William Spears

E-Mail Address: spears@aic.nrl.navy.mil

Citation: Proceedings of the IEEE International Conference on Evolutionary Computation, Anchorage, AK: IEEE, 78-83.

Date: 4-9 May 1998

Report No.: Not assigned

Abstract

A multimodal problem generator was used to test three versions of genetic algorithms and the binary particle swarm algorithm in a factorial time-series experiment. Specific strengths and weaknesses of the various algorithms were identified.

Title: Mobile Robot Exploration and Map Building with Continuous Localization

Author(s): B. Yamauchi, Alan Schultz and William Adams

E-Mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil

Citation: Proceedings of the 1998 IEEE International Conference on Robotics and Automation, Leuven, Belgium: IEEE, 3715-3720.

Date: 16-21 May 1998

Report No.: AIC-97-026

Abstract

Our research addresses how to integrate exploration and localization for mobile robots. A robot exploring and mapping an unknown environment needs to know its own location, but it may need a map in order to determine that location. In order to solve this problem, we have developed ARIEL, a mobile robot system that combines frontier-based exploration with continuous localization. ARIEL explores by navigating to frontiers, regions on the boundary between unexplored space and

space that is known to be open. ARIEL finds these regions in the occupancy grid map that it builds as it explores the world.

ARIEL localizes by matching its recent perceptions with the information stored in the occupancy grid. We have implemented ARIEL on a real mobile robot and tested ARIEL in a real-world office environment. We present quantitative results that demonstrate that ARIEL can localize accurately while exploring, and thereby build accurate maps of its environment.

Title: A Model-Based Approach for Supporting Dialogue Inferencing in a Conversational Case-Based Reasoner
Author(s): David W. Aha and Tucker Maney
E-mail Address: aha@aic.nrl.navy.mil, maney@aic.nrl.navy.mil
Citation: E. Freuder (ed.), Multimodal Reasoning: Proceedings of the 1998 AAAI Spring Symposium, Technical Report SS-98-04, Menlo Park, CA: AAAI Press, 10-15.
Date: 1998
Report No.: AIC-97-023

Abstract
Conversational case-based reasoning (CCBR) is a form of interactive case-based reasoning where users input a partial problem description (in text). The CCBR system responds with a ranked solution display, which lists the solutions of stored cases whose problem descriptions best match the user's, and a ranked question display, which lists the unanswered questions in these cases. Users interact with these displays, either refining their problem description by answering selected questions, or selecting a solution to apply. CCBR systems should support dialogue inferencing; they should infer answers to questions that are implied by the problem description. Otherwise, questions will be listed that the user believes they have already answered. The standard approach to dialogue inferencing allows case library designers to insert rules that define implications between the problem description and unanswered questions. However, this approach imposes substantial knowledge engineering requirements. We introduce an alternative approach whereby an intelligent assistant guides the designer in defining a model of their case library, from which implication rules are derived. We detail this approach, its benefits, and explain how it can be supported through an integration with Parka-DB, a fast relational database system. We will evaluate our approach in the context of our CCBR system, named NaCoDAE.

Title: Modeling Individual Differences in Learning a Navigation Task
Author(s): Diana Gordon, Devika Subramanian, Mary Haught, Robynn Kobayashi and Sandra Marshall
E-mail Address: gordon@aic.nrl.navy.mil
Citation: Proceedings of the Eighteenth Annual Conference of the Cognitive Science Society, Mahwah, NJ: Lawrence Erlbaum Associates, 418-423.
Date: 1998
Report No.: Not assigned

Abstract
Our goal is to develop a cognitive model of how humans acquire skills on complex, sensorimotor tasks. To achieve this goal, we collected data from subjects learning

the NRL Navigation task, then used the data to construct a model that reflects the basic cognitive elements required to learn and thereby succeed at this task (Gordon & Subramanian, 1997). This paper describes a new experiment with human subjects on the task. Data from this experiment not only confirms the key cognitive element of our model, but also helps us better understand individual differences in learning this task. Four evaluation metrics indicate that we are able to model important trends in the evolution of action choice.

Title: NAC: An Adaptive Case-Based Reasoning Tool for Experimenting with Retrieval and Indexing
Author(s): LiWu Chang, Patrick R. Harrison and Laura C. Davis
E-mail Address: lchang@itd.nrl.navy.mil, harrison@aic.nrl.navy.mil
Citation: NRL Memorandum Report NRL/MR/5510--98-8136, Washington: Naval Research Laboratory.
Date: 13 March 1998
Report No.: AIC-98-004

Abstract

NAC is a testbed for experimenting with concepts of retrieval and indexing in Case-Based Reasoning (CBR). The paper describes similarity functions and decision functions used for retrieval as well as methods for re-indexing and case organization. The paper also describes methods for weighing attributes, analyzing their dependence and evaluating the importance index of a single stored case. Two examples of how to use NAC are provided. Methods employed for retrieval and indexing are based on mathematically sound techniques developed in classification, clustering and decision analysis. NAC includes basic functions for specifying similarity, normalizing data and evaluation. Retrieval is done using both nonparametric (e.g., nearest neighbor) and parametric (i.e., Bayesian) statistical procedures with weighted attributes. New indices for cases are generated using clustering methods. Cases are re-organized using the new indices. NAC also allows the user to test the predictive accuracy of retrieval methods and the quality of indices generated in (re)-indexing. NAC includes adaptive functions for enhancing the performance of retrieval and indexing. Important functions for adaptation include weighting and selecting attributes, learning dependency relationships and calculating typicality for each stored case. The NAC environment was designed so that additional techniques and metrics can easily be added.

Title: The Omnipresence of Case-Based Reasoning in Science and Application
Author(s): David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: Knowledge-Based Systems **11**, no. 5-6: 261-273.
Date: 1998
Report No.: AIC-98-002

Abstract

A surprisingly large number of research disciplines have contributed towards the development of knowledge on lazy problem solving, which is characterized by its storage of ground cases and its demand driven response to queries. Case-based reasoning (CBR) is an alternative, increasingly popular approach for designing expert systems that implements this approach. This paper lists pointers to some contributions in some related disciplines that offer insights for CBR research. We

then outline a small number of Navy applications based on this approach that demonstrate its breadth of applicability. Finally, we list a few successful and failed attempts to apply CBR, and list some predictions on the future roles of CBR in applications.

Title: A Probabilistic Framework for Memory-Based Reasoning
Author(s): S. Kasif, S. Salzberg, S. Waltz, J. Rachlin and D.W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: Artificial Intelligence **104**, no. 1-2: 297-312.
Date: 1998
Report No.: Not assigned

Abstract
In this paper, we propose a probabilistic framework for Memory-Based Reasoning (MBR). The framework allows us to clarify the technical merits and limitations of several recently published MBR methods and to design new variants. The proposed computational framework consists of three components: a specification language to define an adaptive notion of relevant context for a query; mechanisms for retrieving this context; and local learning procedures that are used to induce the desired action from this context. We primarily focus on actions in the form of a classification. Based on the framework we derive several analytical and empirical results that shed light on MBR algorithms. We introduce the notion of an MBR transform, and discuss its utility for learning algorithms. We also provide several perspectives on memory-based reasoning from a multi-disciplinary point of view.

Title: Putting More Genetics in Genetic Algorithms
Author(s): Donald S. Burke, Kenneth. A. De Jong, John. J. Grefenstette, Connie. L. Ramsey and Annie. S. Wu
E-mail Address: dejong@aic.nrl.navy.mil, gref@aic.nrl.navy.mil, ramsey@aic.nrl.navy.mil, aswu@aic.nrl.navy.mil
Citation: Evolutionary Computation **6**, no. 4: 387-410.
Date: 1998
Report No.: Not assigned

Abstract
The majority of current genetic algorithms (GAs), while inspired by natural evolutionary systems, are seldom viewed as biologically plausible models. This is not a criticism of GAs, but rather a reflection of choices made regarding the level of abstraction at which biological mechanisms are modeled, and a reflection of the more engineering-oriented goals of the evolutionary computation community. Understanding better and reducing this gap between GAs and genetics has been a central issue in an interdisciplinary project whose goal is to build GA-based computational models of viral evolution. The result is a system called VIV that incorporates a number of more biologically plausible mechanisms including a more flexible genotype-to-phenotype mapping; in VIV the genes are independent of position, and genomes can vary in length and may contain non-coding regions, as well as duplicative or competing genes.

Initial computational studies with VIV have already revealed several emergent phenomena of both biological and computational interest. In the absence of any penalty based on genome length, VIV develops individuals with long genomes and

also performs more poorly (from a problem solving viewpoint) than when a length penalty is used. With a fixed linear length penalty, genome length tends to increase dramatically in the early phases of evolution, and then decrease to a level based on the mutation rate. The plateau genome length (i.e., the average length of individuals in the final population) generally increases in response to an increase in the base mutation rate. When VIV converges, there tends to be many copies of good alternative genes within the individuals. We observed instances of switching between active and inactive genes during the entire evolutionary process. These observations support the conclusion that non-coding regions serve as scratch space in which VIV can explore alternative gene values. These results represent a positive step in understanding how GAs might exploit more of the power and flexibility of biological evolution, while at the same time providing better tools for understanding evolving biological systems.

Title: Quantization Error in Regular Grids: Triangular Pixels
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-Parsi
E-Mail Address: kamgar@aic.nrl.navy.mil, behzad@ait.nrl.navy.mil
Citation: IEEE Transactions on Image Processing **7**, no. 10: 1496-1500.
Date: October 1998
Report No.: Not assigned

Abstract
Quantization of the image plane into pixels results in the loss of the true location of features within pixels and introduces an error in any quantity computed from feature positions in the image. Here we derive closed-form, analytic expressions for the error distribution function, the mean absolute error (MAE), and the mean square error due to triangular tessellation, for differentiable functions of an arbitrary number of independently quantized points, using a linear approximation of the function. These quantities are essential in examining the intrinsic sensitivity of image processing algorithms. Square and hexagonal pixels were treated in previous papers.

Title: The Role of Mutation and Recombination in Evolutionary Algorithms
Author(s): William M. Spears
E-mail Address: spears@aic.nrl.navy.mil
Citation: Ph.D. dissertation, George Mason University, Fairfax, VA.
Date: 1998
Report No.: AIC-98-012

Abstract
Despite decades of work in evolutionary algorithms, there remains a lot of uncertainty as to when it is beneficial or detrimental to use recombination or mutation. This thesis provides a characterization of the roles that recombination and mutation play in evolutionary algorithms. It integrates prior theoretical work and introduces new theoretical techniques for studying evolutionary algorithms. An aggregation algorithm for Markov chains is introduced which is not only useful for studying evolutionary algorithms specifically, but also complex systems in general. Practical consequences of the theory are explored and a novel method for comparing search and optimization algorithms is introduced. A focus on discrete (rather than real- valued) representations allows the thesis to bridge multiple communities, including evolutionary biologists and population geneticists.

Title: Supporting Conversational Case-Based Reasoning in an Integrated
Reasoning Framework
Author(s): David W. Aha, Leonard A. Breslow and Tucker Maney
E-mail Address: aha@aic.nrl.navy.mil, breslow@aic.nrl.navy.mil,
maney@aic.nrl.navy.mil
Citation: D.W. Aha and J.J. Daniels (eds.), Case-based Reasoning Integrations:
Papers from the 1998 Workshop,Technical Report WS-98-15, Menlo Park, CA:
AAAI Press, 7-11.
Date: 1998
Report No.: AIC-98-006

Abstract

Conversational case-based reasoning (CCBR) has been successfully used to assist
in case retrieval tasks. However, behavioral limitations of CCBR motivate the
search for integrations with other reasoning approaches. This paper briefly
describes our group's ongoing efforts towards enhancing the inferencing behaviors
of a conversational case-based reasoning development tool named NaCoDAE. In
particular, we focus on integrating NaCoDAE with machine learning, model-based
reasoning, and generative planning modules. This paper defines CCBR, briefly
summarizes the integrations, and explains how they enhance the overall system.

Title: Supporting Dialogue Inferencing in Conversational Case-Based Reasoning
Author(s): David W. Aha, Tucker Maney and Leonard A. Breslow
E-mail Address: aha@aic.nrl.navy.mil, maney@aic.nrl.navy.mil,
breslow@aic.nrl.navy.mil
Citation: Fourth European Workshop on Case-Based Reasoning, Dublin, Ireland:
Springer, 262-273.
Date: 1998
Report No.: AIC-98-008

Abstract

Dialogue inferencing is the knowledge-intensive process of inferring aspects of a
user's problem from its partial description. Conversational case-based reasoning
(CCBR) systems, which interactively and incrementally elicit a user's problem
description, suffer from poor retrieval efficiency (i.e., they prompt the user with
questions that the user has already implicitly answered) unless they perform
dialogue inferencing. The standard method for dialogue inferencing in CCBR
systems requires library designers to supply explicit inferencing rules. This
approach is problematic (e.g., maintenance is difficult). We introduce an alternative
approach in which the CCBR system guides the library designer in building a
domain model. This model and the partial problem description are then given to a
query retrieval system (PARKA-DB) to infer any implied answers during a
conversation. In an initial empirical evaluation in the NaCoDAE CCBR tool, our
approach improved retrieval efficiency without sacrificing retrieval precision.

Title: Textual Reasoning in the Context of Conversational Case-Based Reasoning Systems
Author(s): David W. Aha
E-Mail Address: aha@aic.nrl.navy.mil
Citation: M. Lenz and K. Ashley (eds.), Textual Case-Based Reasoning: Papers from the 1998 Workshop, Technical Report WS-98-12, Menlo Park, CA: AAAI Press, 1-2.
Date: 1998
Report No.: Not assigned

This report has no abstract.

Title: Unifying Exploration, Localization, Navigation and Planning Through a Common Representation
Author(s): Alan Schultz, William Adams, Brian Yamauchi, and Mike Jones
E-mail Address: schultz@aic.nrl.navy.mil, adams@aic.nrl.navy.mil
Citation: Internal Report.
Date: 1998
Report No.: AIC-98-018

Abstract
The major themes of our research include the creation of mobile robot systems that are robust and adaptive in rapidly changing environments and the view of integration as a basic research issue. Where reasonable, we try to use the same representation to allow different components to work more readily together and to allow better and more natural integration of and communication between these components. In this paper, we summarize our recent work in integrated mobile robot exploration, localization, navigation, and planning.

Title: Well-Behaved Borgs, Bolos, and Berserkers
Author(s): Diana F. Gordon
E-mail Address: gordon@aic.nrl.navy.mil
Citation: Proceedings of the Fifteenth International Conference on Machine Learning, San Francisco: Morgan Kaufman, 224-232.
Date: 1998
Report No.: Not assigned

Abstract
How can we guarantee that our software and robotic agents will behave as we require, even after learning? Formal verification should play a key role but can be computationally expensive, particularly if re-verification follows each instance of learning. This is especially a problem if the agents need to make rapid decisions and learn quickly while online. Therefore, this paper presents novel methods for reducing the time complexity of re-verification subsequent to learning. The goal is agents that are predictable and can respond quickly to new situations.

1997 PUBLICATIONS

AIC-97-001
Extending Local Learners with Error-Correcting Output Codes; Francesco Ricci and David W. Aha

AIC-97-002
Case-Based Learning: Beyond Classification of Feature Vectors; David W. Aha and Dietrich Wettschereck

AIC-97-003
Learning to Refine Case Libraries: Initial Results; David W. Aha and Leonard A. Breslow

AIC-97-004
Refining Conversational Case Libraries; David W. Aha and Leonard A. Breslow

AIC-97-005
ECML-97 MLNet Workshop Notes--Case-Based Learning: Beyond Classification of Feature Vectors; Dietrich Wettschereck and David W. Aha

AIC-97-006
Magellan: A Mobile Robot Integrating Place Recognition, Continuous Localization, and Adaptive Navigation; Brian Yamauchi, Alan Schultz, William Adams, Patrick Langley and John Grefenstette

AIC-97-007
Levels of Evolution for Control Systems; John J. Grefenstette

AIC-97-008
Summary of the 1995 AAAI Fall Symposium on Adaptation of Knowledge for Reuse; David W. Aha and A. Ram

AIC-97-009
Editorial: Lazy Learning; David W. Aha

AIC-97-010
Continuous Localization in Changing Environments; Kevin Graves, William Adams and Alan Schultz

AIC-97-011
ARIEL: Autonomous Robot for Integrated Exploration and Localization; Brian Yamauchi, Alan Schultz, William Adams, Kevin Graves, John Grefenstette and Dennis Perzanowski

AIC-97-012
Cognitive Model of Learning to Navigate; Diana F. Gordon and D. Subramanian

AIC-97-013
Using Problem Generators to Explore the Effects of Epistasis; Kenneth A. De Jong, Mitchell Potter and William M. Spears

AIC-97-014
A Frontier-Based Approach for Autonomous Exploration; Brian Yamauchi

AIC-97-015
Reinforcement Learning Through Evolutionary Computation; D. Moriarty, Alan Schultz and John Grefenstette

AIC-97-016
Asimovian Adaptive Agents; Diana Gordon

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User's Guide to Samuel 97: An Evolutionary System; John Grefenstette

AIC-97-018
NACODAE: Navy Conversational Decision Aids Environment; David W. Aha and Leonard A. Breslow

AIC-97-019
The Functionality of It-clefts in Selected Discourses: The Message in the Medium; Dennis Perzanowski and John Gurney

AIC-97-020
Natural Language in Four Spatial Interfaces; Kenneth Wauchope, Stephanie Everett, Dennis Perzanowski, and Elaine Marsh

AIC-97-021
Integrating Exploration and Localization for Mobile Robots; Brian Yamauchi, Alan Schultz, and William Adams

AIC-97-022
Frontier-Based Exploration Using Multiple Robots; Brian Yamauchi

AIC-97-023
A Model-Based Approach for Supporting Dialogue Inferencing in a

AIC-97-024
The Omnipresence of Case-Based Reasoning in Science and Application; David W. Aha

AIC-97-025
Bias, Variance, and Error Correcting Output Codes for Local Learners; David W. Aha

AIC-97-026
Mobile Robot Exploration and Map-Building With Continuous Localization; Brian Yamauchi, Alan Schultz, and Willam Adams

AIC-97-027
Interruption of People in Human-Computer Interaction: A General Unifying Definition of Human Interruption and Taxonomy; Daniel C. McFarlane

AIC-97-028
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AIC-97-029
Empirical Observations on the Roles of Crossover and Mutation; Annie S. Wu, Robert K. Lindsay, and Rick L. Riolo

AIC-97-030
An Evolutionary Computation Model of Emerging Virus Diseases; John J. Grefenstette, Donald S. Burke, Kenneth A. De Jong, Connie L. Ramsey and Annie S. Wu

AIC-97-031
*Performance Based Design of a New Virtual Locomotion Control*; James N. Templeman

AIC-97-032
Verbal vs. Computer Acknowledgments in High Workload Team Communications; Astrid Schmidt-Nielsen, Kay G. Schulze, and Lisa B. Achille

AIC-97-033
Perceptually Based Scheduling Algorithms for Real-time Synthesis of Complex Sonic Environments; Hesham Fouad, James K. Hahn, and James A. Ballas
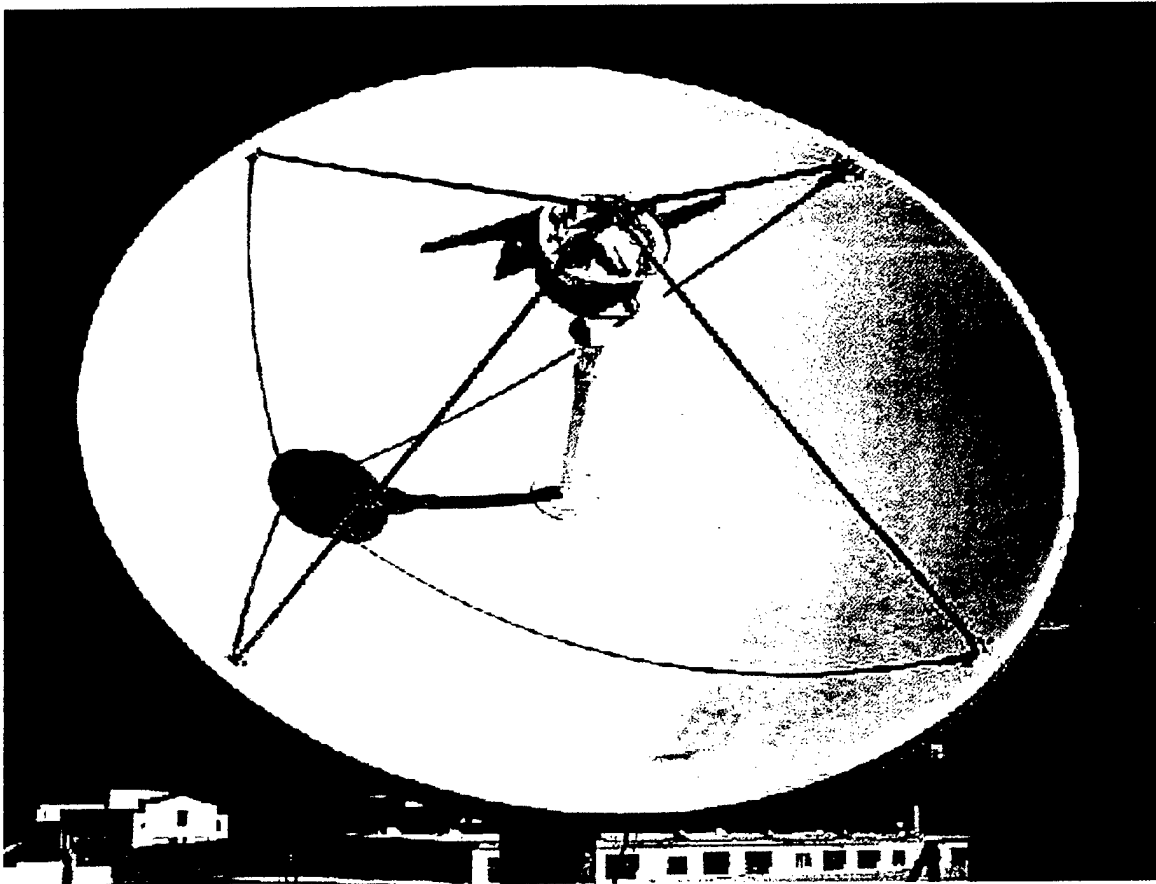
T he Communications Systems Branch is the principal agent for communication system design, analysis, and engineering with emphasis on strategic and tactical communication and networking. Of particular interest is the exploitation of selected components of the global networking grid and the infusion of both commercial and DoD-unique appliques to bring data and voice services to the military user over wire-line, fiber, and wireless networks. Currently, one of our researchers co-chairs the IETF subgroup on Mobile Ad-Hoc Networks (MANET). Current software products include a reliable multicast protocol (Multicast Dissemination Protocol, MDP) and a tactical, network-capable voice-over-IP application (Interactive VOice eXchange, IVOX). Both of these products have been developed to operate over error-prone wireless networks. The Branch is engaged in network design and system performance validation via computer simulation using OPNET and NS2. For some projects the group develops prototype systems for advanced technology demonstrations and also acts as the system engineer. We provide consultation and support to other components of NRL, Navy, and DoD in the areas of communication networking, secure communication equipment, systems design and development, and warfare architecture. We also provide summer intern opportunities for Naval Academy midshipmen.

COMMUNICATON SYSTEMS
Code 5520

Title: Alignment in Ordinal Comparison of DEDS with Application to the Simulation of Communication Networks
Author(s): Liyi Dai and Jeffrey E. Wieselthier
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Proceedings of the 37th IEEE Conference on Decision and Control (CDC'98), Tampa, FL: IEEE, 1668-1673.
Date: December 1998
Report No.: CS-98-015

Abstract
In the design and optimization of *discrete event dynamic systems* (DEDS), it is often necessary to order alternative designs based on their relative performance, i.e., to rank them from best to worst. In this paper, alignment of observed performance orders with true orders is considered, and properties of the alignment are investigated. It is shown that Spearman's rank correlation coefficient converges exponentially in the simulation time or observation time, which gives a strong evidence of the efficiency of order comparison for DEDS. In the context of simulation, the effect of simulation dependence on the alignment is also discussed. It is found that neither independent simulation nor the scheme of *common random numbers* (CRN), a popular scheme for variance reduction, can yield dominant performance. Finally, numerical examples based on a networking optimization problem are provided to illustrate the convergence of Spearman's coefficient. In these examples, the *standard clock* (SC) simulation technique provides much faster convergence than either independent simulation or CRN simulations.

Title: Analysis of Curve Tracer Instruments for Fault Location
Author(s): Joseph A. Molnar
E-mail Address: molner@itd.nrl.navy.mil
Citation: Proceedings of the AUTOTESTCON '98, Salt Lake City, UT: IEEE.
Date: 24-27 August 1998
Report No.: CS-98-009

Abstract
A review of testability, fault isolation algorithms, and fault simulation techniques is performed. Within the context of established theoretical and simulation analysis methods for fault isolation, the use of curve tracer instruments is analyzed. Curve tracer instruments are extensively employed by the military, in repair environments, to aid technicians in the isolation and repair of failed circuit boards. An example circuit is analyzed for testability. The circuit is simulated and the results are compared to results taken from a curve tracer instrument. The results are discussed and the implications for deployment of curve tracer instruments as general fault diagnostic aids for electronic component repair are presented.

Title: Architecture and Concept of Operations for a Warfighter's Internet
Author(s): Air Force Rome Laboratory, Army CECOM, Jet Propulsion Laboratory, MIT Lincoln Laboratory, MITRE Corporation, Navy Command Control Ocean Surveillance Center and Naval Research Laboratory
E-mail Address:
Citation: Appendix Volume 1 and Appendix Volume 2 of report prepared for DARPA.
Date: January 1998
Report No.: Not assigned

This report has no abstract.

Title: A General Class of Error-Detection Codes
Author(s): Gam D. Nguyen
E-mail Address: nguyen@itd.nrl.navy.mil
Citation: Proceedings of the 32nd Annual Conference on Information Sciences and Systems (CISS), Princeton, NJ: Princeton University, 451-453.
Date: 18-20 March 1998
Report No.: Not assigned

Abstract
We present an algorithm for constructing a family of cods that contains optimal codes for detecting errors. This algorithm can be efficiently implemented in software.

Title: Multicasting in Energy-limited Ad-hoc Wireless Networks
Author(s): Jeffrey E. Wieselthier, Gam D. Nguyen and Anthony Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil, nguyen@itd.nrl.navy.mil, tony@eng.umd.edu
Citation: Proceedings of MILCOM '98, Bedford, MA: IEEE, 723-729.
Date: October 1998
Report No.: CS-98-010

Abstract
In this paper, we address the problem of multicasting in military "ad-hoc" wireless networks. Since such networks lack a fixed cellular infrastructure, multicast algorithms that are based on the availability of fixed known topologies cannot be used effectively. Even when the locations of the nodes are fixed and known, the properties of the wireless medium create a networking environment that is vastly different from that of wired networks, and for which the multicasting problem has scarcely been addressed. Specifically, the broadcast nature of wireless transmission and the dependence of range on transmission power create new opportunities for multicasting that need to be traded off against the interference caused by such transmissions. We demonstrate how wireless network characteristics, as well as the constraints of limited energy, affect multicast protocol operation. Preliminary trade-offs are provided, and future research directions are outlined.

Title: Navy Initiatives to Steer COTS Instrument Technology Developments
Author(s): Joseph A. Molnar
E-mail Address: molnar@itd.nrl.navy.mil
Citation: Proceedings of the AUTOTESTCON '98, Salt Lake City, UT: IEEE.
Date: 24-27 August 1998
Report No.: CS-98-007

Abstract
The Navy has purchased commercial-off-the-shelf (COTS) test instrumentation (general purpose electronic test equipment -- GPETE) for over 25 years. Over that period, the Navy has actively engaged the test equipment industry in technical discussions to support technical requirements for instrumentation. A strong customer-supplier relationship has developed that has allowed the Navy to ensure instrument support for emerging requirements using COTS equipment. Now Navy initiatives in instrumentation are focused on supporting improvements in training, extending calibration intervals, automation, and interoperability. These initiatives are being pursued to enhance the Navy's position for a future that will include fewer personnel on ships. The budget for training personnel will be radically constrained; thus, self-training instrumentation will be required. The limited number of personnel will require their instrumentation to be available for longer periods without calibration. Instruments of the future must accommodate automation in an integrated weapons system environment and be able to provide information and raw data back to centralized resources through advanced communications networks. This paper describes the focus of these initiatives for the future Navy.

Title: Network Management Architecture for Expeditionary Warfare Mobile Communications Networking
Author(s): R. K. Nair and D. N. McGregor
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Internal Report.
Date: November 1998
Report No.: Not assigned

Abstract
Communication networks for organizations around the world are growing day by day. The network architecture in support of Naval warfighting is more cumbersome due to the presence of heterogeneous network components including legacy equipment, mobility of network nodes, unstable network links, frequent changes in topology, bandwidth limitations and security requirements. This report addresses network management criteria in managing IP networks and provides solutions for managing large heterogeneous networks. The proposed network management architecture for an Expeditionary Warfare Mobile Communication Networking concept is examined in detail with emphasis on the network management architecture and protocols. A distributed, hierarchical network management architecture is proposed which is compatible with the Naval Automated Digital Network System (ADNS) network management architecture. The proposed architecture is also compatible with the current trends in network management technology and the standards efforts undertaken by the Internet Engineering Task Force (IETF). This report also examines the recent areas of development in network management including distributed discovery and monitoring, fault correlation, and performance data collection. Finally, this report considers various

COTS software packages currently available in the areas of extensible SNMP agent development, and fault correlation.

Title: On the Maximum Throughput of Wireless Circuit-Switched Networks Under QoS Constraints
Author(s): Jeffrey E. Wieselthier, Gam D. Nguyen and Anthony Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil, nguyen@itd.nrl.navy.mil
Citation: Kin K. Leung and Branimir Vojcic (eds.), Proceedings of the Multiaccess, Mobility and Teletraffic for Wireless Communications (MMT'98), Vol. 3, Washington, DC: Kluwer Academic Publishers, 219-236.
Date: October 1998
Report No.: CS-98-014

Abstract
We consider the off-line determination of the offered load that maximizes throughput in circuit-switched, wireless multihop networks, subject to Quality of Service (QoS) constraints on circuit blocking probability. This problem is of interest in network design for "sizing" the service capabilities that can be provided. We consider a rigorous formulation of the problem as a nonlinear optimization problem with nonlinear inequality constraints, and employ Lagrangian techniques for its solution. We develop several heuristic variations of the basic technique that improve the speed and accuracy of the search, and we demonstrate that there can be significant increase of the achievable throughput value via the optimization method as compared to other ad-hoc techniques for the maximization of throughput.

Title: Ordinal Optimization of Communication Network Performance: A New Look Based on Use of the Connection Machine
Author(s): J. E. Wieseltheir, C. M. Barnhart and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: NRL Memorandum Report NRL/MR/5521--98-8165, Washington, DC: Naval Research Laboratory.
Date: August 1998
Report No.: Not assigned

Abstract
Ordinal optimization can be an effective technique for efficiently finding nearly optimal solutions to complex problems. The motivation behind this approach is that finding the optimal solution (or control policy) is often too costly or time consuming, although a suboptimal solution may provide sufficiently good performance. In earlier studies on sequential machines, we demonstrated the effectiveness of ordinal optimization based on the Standard Clock (SC) parallel simulation technique. In this report we study the use of SC and ordinal optimization techniques on the massively parallel Connection Machine CM-5E.

The use of the CM-5E has greatly extended the size of problems that can be addressed. For example, whereas our studies on sequential machines were typically limited to wireless networking examples with up to 8 transceivers per node, the use of the CM-5E has permitted the study of examples with up to 4,000 transceivers per node, thus permitting the study of examples with the dimensions of high-speed networks. We address self-regulation and scalability properties of

the solutions, as well as the determination of good solutions for large, finely-quantized systems. The CM-5E has enabled us to demonstrate that good solutions can be found quickly, and often without the need for high-performance computer resources.

Title: Revised SG-1157/U Digital Processing Clock, Operations and Maintenance Manual with ID-2170/U Remote Time Readout Unit
Author(s): Thomas H. Gattis, Joseph A. Molnar and Joseph J. O'Neill
E-mail Address: molner@itd.nrl.navy.mil
Citation: NRL Publication NRL/PU/5520--98-0008, Washington: Naval Research Laboratory.
Date: 1 June 1998
Report No.: CS-98-008

Abstract
The model SG-1157/U Digital Processing Clock, and Model ID-2170/U, Remote Time Readout, equipments are used on all SSN 688 class submarines for generation of precise timing signals and display of the time-of-day information. The SG-1157/U operates with an external standard such as the 0-169/U or 0-1824/U Cesium Beam Frequency Standard or from its own internal oscillator when a reference standard is not available. Several timing signal outputs are provided, such as 1 pps, 1 pp 10 s, time of event, parallel time code and the XR-3 serial time code. The SG-1157/U is capable of simultaneously driving four ID-2170/U Remote Time Readouts and one XR-3 time code display. Details of a redesigned 2137 Time Code Generator board are provided. The redesigned board is referred to as a B Series A8 Circuit Board. This board provides added circuit drive capability and replaces expensive or difficult to obtain parts. Internal batteries are provided to permit continuous operation for up to thirty (30) minutes during alternating current (AC) power interruptions.

Title: Sizing of Network Throughput Capability Subject to QoS Constraints on Average Blocking Probability
Author(s): Jeffrey E. Wieselthier, Gam D. Nguyen and Anthony Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil, nguyen@itd.nrl.navy.mil, tony@eng.umd.edu
Citation: Proceedings of the 32nd Annual Conference on Information Sciences and Systems (CISS), Princeton, NJ: Princeton University, 757-758.
Date: 18-20 March 1998
Report No.: CS-98-002

Abstract
A problem of interest in circuit-switched networks is to determine off-line the maximum traffic volume they can carry under various constraints on quality of service. In particular, for a given set of routing paths it is of interest to "size" the network's throughput capability under constraints on blocking probability. In earlier work we have considered this problem when the constraint on blocking probability applies to every circuit in the network, and developed an optimization technique based on Lagrangian methods that proved to converge reasonably well and to yield a good estimate of the maximum traffic that the network might carry. In this paper we extend and modify our previous work in a number of ways. We use the same basic circuit-switched model with the standard exponential/Markovian assumptions

on traffic loads and cell durations. We continue to keep the set of routing paths fixed (the maximum achievable throughput depends on the routes; we do not consider here the problems of selecting optimal routes, which is nonetheless a very important concern in circuit-switched networks), but place the constraint on the *average* blocking probability across all source-destination pairs. This difference is significant both philosophically and analytically. It takes a different view of service guarantees (consistent with network revenue optimization), and it results in a "smoother" search volume that permits the Lagrangian methods to converge faster and that yields a higher throughput value. Although all of our examples represent the case of wireless networks, our formulation is also applicable to wired networks.

Title: Some Issues on Turbo Codes and DoD Applications
Author(s): D. N. McGregor
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Presentation at the ONR and NRL sponsored Workshop on Turbo Codes, Naval Research Laboratory, Washington, DC.
Date: December 1998
Report No.: Not assigned

Abstract
Turbo Coding is a promising technology that offers performance approaching the Shannon limit (AWGN channel) within about a dB or less. Therefore, it offers an improvement of 3 to 5 dB in performance (2 to 3 increase in capacity) over conventional rate 1/2 coded systems. This increase in capacity should prove extremely beneficial to many DoD applications. However, there is much research (including implementation issues) that still needs to be done to make this gain achievable. We need to identify where turbo codes are appropriate in the military environment (e.g., AWGN vs. other tactical channels of interest which are corrupted by fading, interference, and jamming). In addition, we need to understand any limitations associated with turbo coding such as noise floor problems, data rate limitations, performance vs. complexity, implementation, robustness. latency effects caused by the interleaver frame which would have a major impact on voice applications, and so forth. We are attempting to establish a "Joint Service" program in this area to assess turbo code technology and examine where it can be beneficial to DoD. The long-term goal of such a joint effort would be to target this technology into the Joint Tactical Radio System (JTRS) program.

1997 Publications

CS-97-001
Lagrangian Techniques for Optimizing Throughput in Wireless Communication Networks Subject to QoS Constraints; Gam D. Nguyen, Jeffrey E. Wieselthier and Anthony Ephremides

CS-97-002
Ordinal Optimization of Discrete-Event Dynamic Systems: A Comparison of Standard Clock and Common-Random-Number Methods; Jeffrey E. Wieselthier, Craig M. Barnhart and Anthony Ephremides

CS-97-003
Design, Implementation, and Use of a Real-Time, Distributed Simulation Testbed for Mobile Communication Networks; Dennis J. Baker

CS-97-004
Protocols to Support Integrated Services in a Mobile Cellular System Architecture; James P. Hauser, Dale F. Lindquist and R.K. Nair

CS-97-005
Hardware-In-The Loop Simulation and Prototyping with OPNET; John S. Schlorff and Donald G. Kallgren

CS-97-006
Classification of Error Locator Polynomials for Double Error Correcting BCH Codes; Paul J. Crepeau

CS-97-007
A Polynomial Construction of Perfect Codes; Gam D. Nguyen

CS-97-008
Summary and Applicability of Analog Fault Detection/Isolation Techniques; J. A. Molnar

CS-97-009
W-Band Synthesized Signal Generator using Fundamental Voltage Controlled Oscillators; J. A. Molnar and R. Zborofsky

CS-97-010
Service Model and Cell Multiplexing for the Data and Voice Integration Advanced Technology Demonstration; James P. Hauser

CS-97-011
Algorithms for Finding Optimal Offered Load in Wireless Communication Networks; Jeffrey E. Wieselthier, Gam D. Nguyen and Anthony Ephremides

CS-97-012
Strategic Alliance for Advanced Navy COTS Test Equipment; J. A. Molnar

CS-97-013
Three Techniques for Ordinal Optimization: Short Simulation Runs, Crude Analytical Models, and Imprecise Simulation Models; J.E. Wieselthier

CS-97-014
STOW Network Technologies and Operational Lessons Learned; Ray Cole, Barth Rose, Larry O'Ferrall, Julie Tarr and LTC Paul Myers

CS-97-015
A Recommended Error Control Architecture for ATM Networks with Wireless Links; J.B. Cain and D.N. McGregor

CS-97-016
Performance and Resource Cost Comparisons for the CBT and PIM Multicast Routing Protocols; T. Billhartz, J.B. Cain, E. Farrey-Goudreau, D. Fieg and S.G. Batsell

CS-97-017
Naval Research Laboratory's Data/Voice ATD: HF Data/Voice Network; D.J. Baker

CS-97-018
Littoral Forces Communication; D.N. McGregor

CS-97-019
Networking Concepts Using SINCGARS SIP/INC Technology to Support Tactical Communications for Expeditionary Warfare Operations.; D.N. McGregor and E.I. Althouse

CS-97-020
Use of SINCGARS in Littoral/Expeditionary Warfare; J.B. Cain, et al.

CS-97-021
Joint Littoral Warfare Tactical Communications Requirements Analysis; J. Lovuola

CS-97-022
Remote Digital Antenna Current Meter Modification; T. H. Gattis

Developing High Assurance Building Blocks

T he Center for High Assurance Computer Systems (CHACS) performs research and develops technology in areas supporting military requirements for communication security (COMSEC) and computer security (COMPUSEC). Emphasis is given to the development of concepts, architectures, analysis techniques and methodology that exploit appropriately the opportunities available through systematic consideration of the total security problem and its impact on communication and computer systems. The Center provides leadership and is the Navy's lead laboratory for research and development of COMPUSEC technology and evaluation techniques. Areas of activity include development of information security devices, subsystems and system technology through the conceptual, analysis and experimentation, and proof-of-concept phases. The Center works closely with Navy system developers and with the National Security Agency.

CENTER FOR HIGH ASSURANCE COMPUTER SYSTEMS
Code 5540

Title: Agent Trustworthiness
Author(s): Lora Kassab and Jeffrey Voas
E-mail Address:
Citation: Proceedings of ECOOP Workshop on Distributed Object Security and 4th Workshop on Mobile Object Systems Secure Internet Mobile Computations, Brussels: INRIA, 121-134.
Date: 20-21 July 1998
Report No: CHACS-98-013

Abstract
Agent-based technology could revolutionize the manner by which distributed computation is performed. The fact that the information returned by an agent to the agent owner cannot be validated by the owner is impeding the widespread adoption of agent-based computing. Our paper addresses this concern by proposing a new type of software assertion to increase observability by providing agent owner's with agent state "snap-shots." These snap-shots provide agent owners with: (1) a means to determine whether its agent's results are trustworthy, (2) information to debug a roving agent, (3) a greater ability to meet real-time constraints, and (4) a means to identify hosts systems that are resource-deficient, grant insufficient access rights, or tamper with agents. We present a methodology and tool for selecting and embedding protective assertions into agent code. We also discuss how the information from the assertions is automatically analyzed. Although our proposed assertions are not foolproof, they make it much harder for an agent to be tampered with in ways that are not detectable by the agent's owner. This knowledge is paramount for the utility of an agent-based system.

Title: An Analysis of the Timed Z Channel
Author(s): Ira S. Moskowitz, Steven J. Greenwald and Myong H. Kang
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: IEEE Transactions on Information Theory **44**, no. 7: 3162-3168.
Date: November 1998
Report No: CHACS-98-023

Abstract
Golomb analyzed the Z-channel, a memoryless channel with two input symbols and two input symbols and two output symbols, where one of the input symbols is transmitted with noise while the other is transmitted without noise, and the output symbol transmission times are equal. We generalize to the timed Z-channel appears as the basis for a large class of covert (communication) channels appearing in multilevel secure computer systems. We give a detailed mathematical analysis of the timed Z-channel and report a result expressing the capacity of the timed Z-channel as the log of the root of a characteristic equation. This generalizes Shannon's work on noiseless channels for this special case. We also report a new result bounding the timed Z-channel's capacity from below. We show how an

interesting observation that Golomb reported for the Z-channel also holds for the timed Z-channel.

Title: Anonymous Connections and Onion Routing
Author(s): Michael G. Reed, Paul F. Syverson and David M. Goldschlag
E-mail Address: reed@itd.nrl.navy.mil, syverson@itd.nrl.navy.mil
Citation: IEEE Journal on Selected Areas in Communication Special Issue on Copyright and Privacy Protection **16**, no. 4: 482-494.
Date: May 1998
Report No: CHACS-98-019

Abstract
Onion Routing is an infrastructure for private communication over a public network. It provides anonymous connections that are strongly resistant to both eavesdropping and traffic analysis. Onion routing's anonymous connections are bi-directional and near real-time, and can be used anywhere a socket connection can be used. (In some contexts not even socket connections are needed to use onion routing.) Any identifying information must be in the data stream carried over an anonymous connection. An onion is a data structure that is treated as the destination address by onion routers; thus, it is used to establish an anonymous connection. Onions themselves appear differently to each onion router as well as to network observers. The same goes for data carried over the connections they establish. Proxy aware applications, such as web browsing and email, require no modification to use onion routing, and do so through a series of proxies. A prototype of onion routing is running in our lab. This paper describes anonymous connections and their implementation using onion routing. This paper also describes several application proxies for onion routing, as well as configurations of onion routing networks.

Title: Applying the SCR Requirements Method to a Weapons Control Panel: An Experience Report
Author(s): Constance L. Heitmeyer, James C. Kirby, Jr., and Bruce Labaw
E-mail Address: heitmeyer@itd.nrl.navy.mil, kirby@itd.nrl.navy.mil
Citation: Proceedings of the Formal Methods in Software Practice (FMSP '98), Clearwater Beach, FL: ACM, 92-102.
Date: 4-5 March 1998
Report No: CHACS-98-006

Abstract
A major barrier to the use of formal methods in software practice is the difficulty software developers have understanding and applying the methods. To overcome this barrier, a requirements method called SCR (Software Cost Reduction) offers a user-friendly tabular notation to specify software requirements and a collection of easy-to-use tools that automatically detect many classes of errors in requirements specifications.

This paper describes our experience in applying the SCR method and tools to a safety-critical military application---the problems encountered in translating the original contractor-produced software requirements specification into SCR and the lessons learned in applying the SCR technology to a practical system. The short time required to apply the SCR method, the serious safety violation detected, and

the working system prototype produced demonstrate the utility and potential cost-effectiveness of SCR or developing safety-critical systems.

Title: Automatic Generation of State Invariants from Requirements Specifications
Author(s): Ralph D. Jeffords and Constance L. Heitmeyer
E-mail Address: jeffords@itd.nrl.navy.mil, heitmeyer@itd.nrl.navy.mil
Citation: Proceedings of the 6th International Symposium on the Foundations of
    Software Engineering (FSE-6), Orlando FL: ACM, Software Engineering Notes **23**,
    No. 6, 56-69.
Date: 3-5 November 1998
Report No: CHACS-98-009

Abstract
Automatic generation of state invariants, properties that hold in every reachable state of a state machine model, can be valuable in software development. Not only can such invariants be presented to system users for validation, in addition, they can be used as auxiliary assertions in proving other invariants. This paper describes an algorithm for the automatic generation of state invariants that, in contrast to most other such algorithms, which operate on programs, derives invariants from requirements specifications. Generating invariants from requirements specifications rather than programs has two advantages: 1) because requirements specifications, unlike programs, are at a high level of abstraction, generation of and analysis using such invariants is easier, and 2) using invariants to detect errors during the requirements phase is considerably more cost-effective than using invariants later in software development. To illustrate the algorithm, we use it to generate state invariants from requirements specifications of an automobile cruise control system and a simple control system for a nuclear plant. The invariants are derived from specifications expressed in the SCR (Software Cost Reduction) tabular notation.

Title: Bayesian Methods Applied to the Database Inference Problem
Author(s): LiWu Chang and Ira S. Moskowitz
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: Proceedings of the 12th Annual International Federation for Information
    (IFIP) Working Conference on Database Security, Vol. 113, Chalkidiki, Greece:
    Kluwer.
Date: 15-17 July 1998
Report No: CHACS-98-024

Abstract
We apply Bayesian estimation and network techniques to the database inference problem. Bayesian analysis permits the realistic estimation of probabilities of missing data as well as insight into how prior knowledge and observed data interact. We urge our community to exploit this powerful tool.

Title: Design and Assurance Strategy for the NRL Pump
Author(s): Myong H. Kang, Andrew P. Moore and Ira S. Moskowitz
E-mail Address: moore@itd.nrl.navy.mil, moskowit@itd.nrl.navy.mil
Citation: IEEE Computer Magazine **31**, no. 4: 56-64.
Date: April 1998
Report No: CHACS-98-010

Abstract
The NRL Pump forwards messages from a low-level system to a high-level system
and monitors the timing of acknowledgments from the high system to minimize
leaks. It is the keystone to a proposed architecture that uses specialized high-
assurance devices to separate data at different security levels.

Title: Formal Methods for Developing High Assurance Computer Systems: Working
Group Report
Author(s): Mats P.E. Heimdahl and Constance L. Heitmeyer
E-mail Address: heitmeyer@itd.nrl.navy.mil
Citation: Proceedings of the Second IEEE Workshop on Industrial-Strength Formal
Techniques (WIFT'98), Boca Raton, FL: IEEE, 60-64.
Date: 19 October 1998
Report No: CHACS-98-003

Abstract
This paper presents the results of a discussion conducted at the Workshop on
Industrial-Strength Form Techniques in October 1998 on the topic, "Formal
Methods for Developing High Assurance Systems." It addresses three issues: the
uses of formal methods in software development, the barriers to the use of formal
methods in software development, and approaches to overcoming the barriers.

Title: A Formal Specification of Requirements for Payment Transactions in the SET
Protocol
Author(s): Catherine Meadows and Paul F. Syverson
E-mail Address: meadows@itd.nrl.navy.mil, syverson@itd.nrl.navy.mil
Citation: Proceedings of Financial Cryptography 98, Anguilla, British West Indies:
Springer-Verlag, 122-140.
Date: 23-26 February 1998
Report No: CHACS-98-017

Abstract
Payment transactions in the SET (Secure Electronic Transaction) protocol are
described. Requirements for SET are discussed and formally represented in a
version of NPATRL (the NRL Protocol Analyzer Temporal Requirements Language).
NPATRL is language for expressing generic requirements, heretofore applied to key
distribution or key agreement protocols. Transaction vectors and other new
constructs added to NPATRL for reasoning about SET payment transactions are
described along with properties of their representation.

Title: How to Construct Formal Arguments that Persuade Certifiers
Author(s): Andrew P. Moore, J. Eric Klinker and David M. Mihelcic
E-mail Address: moore@itd.nrl.navy.mil
Citation: M. G. Hinchey and J. P. Bowen (eds.), Industrial Strength Formal Methods, London: Springer Verlag.
Date: June 1998
Report No: CHACS-98-018

Abstract
Developers of a critical system must argue that the system satisfies its critical requirements -- those that, if not satisfied, could result in human injury or death, substantial loss of capital, or the compromise of national security. Documenting an explicit, persuasive assurance argument is especially important when the system produced must be evaluated and approved by an independent certifier, as is often the case for safety- and security-critical systems. Past experience developing independently evaluated systems using formal methods demonstrates that the presentation of the assurance argument is as important as the rigor of the assurance evidence on which that argument is based. Formal specifications and analyses must be presented coherently in the context of the overall system decomposition or much of their power to persuade may be lost.

This paper describes and illustrates a general framework that supports gathering, integrating, presenting and reviewing the evidence that we can trust a system to conform to its critical requirements. Our framework enables a developer to produce understandable, coherent and relevant assurance arguments that use formal methods. This is not a step-by-step guide, but a set of guidelines within which individual organizations can customize or improve their existing software development process to use formal methods as an effective tool for convincing an independent certifier of a system's trustworthiness. We describe application of our framework to several examples including one for which we produced a verified software/hardware implementation. The real-world examples provided are simple enough to demonstrate concretely and concisely how to put into practice the techniques on which our framework is based.

Title: Internetwork Traffic Management Enhancements: Evaluation on and Experimental Results
Author(s): Joseph P. Macker and V. Park
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Proceedings of the IEEE Military Communications Conference (MILCOM 98), Boston, MA: IEEE.
Date: 18-21 October 1998
Report No.: Not assigned

This report has no abstract.

Title: A Logical Approach to Multilevel Security of Probabilistic Systems

Author(s): James W. Gray, III and Paul F. Syverson
E-Mail Address: syverson@itd.nrl.navy.mil

Abstract

We set out a modal logic for reasoning about multilevel security of probabilistic systems. This logic contains expressions for time, probability, and knowledge. Making use of the Halpern-Tuttle framework for reasoning about knowledge and probability, we give a semantics for our logic and prove it is sound. We give two syntactic definitions of perfect multilevel security and show that their semantic interpretations are equivalent to earlier, independently motivated characterizations. We also discuss the relation between these characterizations of security and between their usefulness in security analysis.

Title: Mechanical Verification of Timed Automata: A Case Study

Author(s): Myla M. Archer and Constance L. Heitmeyer
E-mail Address: archer@itd.nrl.navy.mil, heitmeyer@itd.nrl.navy.mil

Abstract

This report describes the results of a case study on the feasibility of developing and applying mechanical methods, based on the proof system PVS, to prove propositions about real-time systems specified in the Lynch-Vaandrager timed automata model. In using automated provers to prove propositions about systems described by a specific mathematical model, both the proofs and the proof process can be simplified by exploiting the special properties of the mathematical model. Because both specifications and methods of reasoning about them tend to be repetitive, the use of a standard template for specifications, accompanied by standard shared theories and standard proof strategies or tactics, is often feasible. Presented are the PVS specification of three theories that underlie the timed automata model, a template for specifying timed automata models in PVS, and an example of its instantiation. Both hand proofs and the corresponding PVS proofs of two propositions are provided to illustrate how these can be made parallel at different degrees of granularity. Our experience in applying PVS to specify and reason about real-time systems modeled as timed automata is also discussed. The methods for reasoning about timed automata in PVS developed in the study have evolved into a system called TAME (Timed Automata Modeling Environment). A summary of recent developments regarding TAME is provided. A shorter version of the report was presented at the 1996 Real-Time Applications Symposium.

Title: Mobile Ad Hoc Networking and the IETF
Author(s): Joseph P. Macker and M. S. Corson
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Mobile Computing and Communications Review **2**, No. 1: 9-15.
Date: January 1998
Report No.: Not assigned

Abstract

This article is the first in a series intended to chronicle the status of work underway within the Mobile Ad hoc NETworks (MANET) Working Group of the Internet Engineering Task Force (IETF). This article provides a short history and high-level, conceptual tutorial of MANET technology. We present an overview of the working group's vision and charter, and a glimpse into a technical architecture under consideration for achieving this vision.

Title: Mobile Ad Hoc Networking and the IETF
Author(s): Joseph P. Macker and M. S. Corson
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Mobile Computing and Communication Review **2**, No. 2: 9-13.
Date: April 1998
Report No.: Not assigned

Abstract

This article provides a snapshot of work underway within the Mobile Ad hoc NETworks (MANET) Working Group of the Internet Engineering Task Force (IETF). The article presents some issues currently under discussion on the MANET mailing list, and also summarizes the proceedings of the last MANET WG meeting.

Title: Mobile Ad Hoc Networking and the IETF
Author(s): Joseph P. Macker and M. S. Corson
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Mobile Computing and Communication Review **2**, No. 3: 7-10.
Date: July 1998
Report No.: Not assigned

Abstract

This article provides a snapshot of work underway within the Mobile Ad hoc NETworks (MANET) Working Group of the Internet Engineering Task Force (IETF). The article summarizes the proceedings of the last MANET WG meeting, presents some issues currently under discussion on the MANET mailing list (manet@itd.nrl.navy.mil), and gives some rationale behind the architectural design approach being promoted within the group.

Title: Mobile Ad Hoc Networking and the IETF
Author(s): Joseph P. Macker and M. S. Corson
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Mobile Computing and Communication Review **2**, No. 4: 9-14.
Date: October 1998
Report No.: Not assigned

Abstract
This article provides a snapshot of work underway within the Mobile Ad hoc NETworks (MANET) Working Group of the Internet Engineering Task Force (IETF). The article summarizes the proceedings of the last MANET WG meeting, presents some issues currently under discussion on the MANET mailing list (manet@itd.nrl.navy.mil), and gives some rationale behind the architectural design approach being promoted within the group.

Title: On Certain Generalized Incomplete Gamma Functions
Author(s): Allen R. Miller and Ira S. Moskowitz
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: Journal of Computational and Applied Mathematics **91**: 179-190.
Date: November 1998
Report No: CHACS-98-022

Abstract
Recently, Chaudhry and Zubair have introduced a generalized incomplete gamma function $\Gamma(v, x: z)$ which reduces to the incomplete gamma function $\Gamma(v, x)$ when its variable z vanishes. We show that $\Gamma(v, x: z)$ may be written essentially as a single Kamp'e de F'eriet function which in turn may be expressed as a linear combination of two incomplete Weber integrals. Then by using properties of the latter integrals we deduce additional representations for $\Gamma(v, x: z)$. In particular, we show that $\Gamma(v, x: z)$ is essentially completely determined by a finite number of modified Bessel functions for all $v \neq 0$ provided we know the values of the two incomplete Weber integrals when $0 < \text{Re } v \leq 1$. When $v = 0$ we derive connections between the generalized incomplete gamma function and incomplete Lipschitz-Hankel integrals, and indicate that there exist connections with other special functions.

Title: On the Need for "Practical" Formal Methods
Author(s): Constance L. Heitmeyer
E-mail Address: heitmeyer@itd.nrl.navy.mil
Citation: Proceedings of the Fifth International Symposium on Formal Techniques in Real-Time and Real-Time Fault-Tolerant Systems (FTRTFT'98), Lyngby, Denmark: Springer, Lecture Notes in Computer Science 1486, 18-26. Invited paper.
Date: 14-18 September 1998
Report No: CHACS-98-004

Abstract
A controversial issue in the formal methods community is the degree to which mathematical sophistication and theorem proving skills should be needed to apply a formal method. A fundamental assumption of this paper is that formal methods research has produced several classes of analysis that can prove useful in software

development. However, to be useful to software practitioners, most of whom lack advanced mathematical training and theorem proving skills, current formal methods need a number of additional attributes, including more user-friendly notations, completely automatic (i.e., pushbutton) analysis, and useful, easy to understand feedback. Moreover, formal methods need to be integrated into a standard development process. I discuss additional research and engineering that is needed to make the current set of formal methods more practical. To illustrate the ideas, I present several examples, many taken from the SCR (Software Cost Reduction) requirements method, a formal method that software developers can apply without theorem proving skills, knowledge of temporal and higher order logics, or consultation with formal methods experts.

Title: Parsimonious Downgrading and Decision Trees Applied to the Inference Problem
Author(s): LiWu Chang and Ira S. Moskowitz
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: Proceedings of the New Security Paradigms Workshop, Charlottesville, VA: 82-89.
Date: 22-26 September 1998
Report No: CHACS-98-025

Abstract
In this paper we present our new paradigm for dealing with the inference problem which arises from downgrading. Our new paradigm has two main parts: the application of decision tree analysis to the inference problem, and the concept of parsimonious downgrading. We also include a new thermodynamically motivated way of dealing with the deduction of inference rules from partial data.

Title: Reliable Multicast and Integrated Parity Retransmission with Channel Estimation
Author(s): Joseph P. Macker and D. Gossink
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Proceedings of the IEEE Global Telecommunications Conference (GLOBECOM 98), Sydney, Australia: IEEE.
Date: 8-12 November 1998
Report No.: Not assigned

This report has no abstract.

Title: SCR: A Practical Method for Requirements Specification
Author(s): Constance L. Heitmeyer
E-mail Address: heitmeyer@itd.nrl.navy.mil
Citation: Proceedings of the AIAA/IEEE/SAE Digital Avionics Systems Conference (17th DASC), Bellevue, WA: IEEE, C44-1-C44-5.
Date: November 1998
Report No: CHACS-98-021

Abstract
A controversial issue in the formal methods research community is the degree to which mathematical sophistication and theorem proving skills should be needed to

apply a formal method. A premise of this paper is that formal methods research has produced several techniques. In the paper, several attributes needed to make a formal method useful in practice are described. These attributes include user-friendly notation, automated (I.e., push-button) analysis, and easy to understand feedback. To illustrate the attributes of a practical formal method, a formal method for requirements specification called SCR (Software Cost Reduction) is introduced.

Title: SCR*: A Toolset for Specifying and Analyzing Software Requirements
Author(s): Constance L. Heitmeyer, James C. Kirby, Jr., Bruce Labaw and Ramesh Bharadwaj
E-mail Address: heitmeyer@itd.nrl.navy.mil, kirby@itd.nrl.navy.mil, ramesh@itd.nrl.navy.mil
Citation: Proceedings of the Tenth Annual Conference on Computer-Aided Verification (CAV'98), Vancouver, Canada: Springer, Lecture Notes in Computer Science 1427, 526-531.
Date: June-July 1998
Report No: CHACS-98-005

Abstract
A controversial issue in the formal methods community is the degree to which mathematical sophistication and theorem proving skills should be needed to apply a formal method and its support tools. This paper describes the SCR (Software Cost Reduction) tools, part of a "practical" formal method--a method with a solid mathematical foundation that software developers can apply without theorem proving skills, knowledge of temporal and higher order logics, or consultation with formal methods experts. The SCR method provides a tabular notation for specifying requirements and a set of "light-weight" tools that detect several classes of errors automatically. The method also provides support for more "heavy-duty" tools, such as a model checker. To make model checking feasible, users can automatically apply one or more abstraction methods.

Title: A Survey of Multicast Security Issues and Architectures
Author(s): Peter Kruus
E-mail Address:
Citation: Proceedings of 21st National Information Systems Security Conference, Arlington, VA: NIST, 408-420.
Date: 5-8 October 1998
Report No: CHACS-98-015

Abstract
This paper addresses issues relevant to implementing security for IP multicast networks. These issues are of importance to application developers wishing to implement security services for their multicast applications. The paper investigates the steps required to create a secure multicast session including issues of group membership and key distribution. A common simple criteria is established that can be used to evaluate multicast keying architectures. The criteria focuses on the efficiency and scalability of the keying solution. Using this criteria, several keying architectures are evaluated and compared to determine their strengths and weaknesses.

Title: TAME: A PVS Interface to Simplify Proofs for Automata Models
Author(s): Myla M. Archer, Constance L. Heitmeyer and Steve Sims
E-mail Address: archer@itd.nrl.navy.mil, heitmeyer@itd.nrl.navy.mil
Citation: Proceedings of the User Interfaces for Theorem Provers (UITP '98),
     Eindhoven, Netherlands: Eindhoven University of Technology, 42-49.
Date: July 1998
Report No: CHACS-98-001

Abstract
Although a number of mechanical provers have been introduced and applied widely
by academic researchers, these provers are rarely used in the practical
development of software. For mechanical provers to be used more widely in
practice, two major barriers must be overcome. First, the languages provided by the
mechanical provers for expressing the required system behavior must be more
natural for software developers. Second, the reasoning steps supported by
mechanical provers are usually at too low and detailed a level and therefore
discourage use of the prover. To help remove these barriers, we are developing a
system called TAME, a high-level user interface to PVS for specifying and proving
properties of automata models. TAME provides both a standard specification format
for automata models and numerous high-level proof steps appropriate for
reasoning about automata models. In previous work, we have shown how TAME can
be useful in proving properties about systems described as Lynch-Vaandrager
Timed Automata models. TAME has the potential to be used as a PVS interface for
other specification methods that are specialized to define automata models. This
paper first describes recent improvements to TAME, and then presents our initial
results in using TAME to provide theorem proving support for the SCR (Software
Cost Reduction) requirements method, a method with a wide range of other
mechanized support.

Title: Techniques and Issues in Multicast Security
Author(s): Peter Kruus and Joseph P. Macker
E-mail Address: macker@itd.nrl.navy.mil
Citation: Proceedings of the IEEE Military Communications Conference (MILCOM
     98), Boston, MA: IEEE.
Date: 18-21 October 1998
Report No: CHACS-98-016

Abstract
 Multicast networking support is becoming an increasingly important future
technology area for both commercial and military distributed and group-based
applications. Integrating a multicast security solution involves numerous
engineering tradeoffs. The end goal of effective operational performance and
scalability over a heterogeneous inter-network is of primary interest for wide-scale
adoption and application of such a capability. Various techniques that have been
proposed to support multicast security are discussed and their relative merits are
explored.

Title: The Temporally Ordered Routing Algorithm (TORA)
Author(s): V. Park, M. S. Corson and Joseph P. Macker
E-Mail Address: macker@itd.nrl.navy.mil
Citation: Proceedings of the IEEE Military Communications Conference (MILCOM 98), Boston, MA: IEEE.
Date: 18-21 October 1998
Report No.: Not assigned

This report has no abstract.

Title: Towards Fault-tolerant Mobile Agents
Author(s): Lora Kassab and Jeffrey Voas
E-mail Address:
Citation: Proceedings of Distributed Computing on the Web Workshop (DCW ' 98), Rostock, Germany: University of Rostock Press, 96-106.
Date: June 1998
Report No: CHACS-98-014

 Abstract
The absence of a trusted computing base for mobile agents poses serious security issues for both the host system and the survivability of the agent. Once a mobile agent is dispatched, asserting anything about the host system, the agent's behavior, or even the agent's existence is difficult to ascertain. In order to employ agents with any degree of confidence, constraints need to be placed on the agent computation since no restraints can be imposed (or assumed) about the host system's hardware or software. This paper presents a fault-tolerant approach for increasing an agent owner's confidence in the integrity of its agent.

Title: Towards Formalizing the Java Security Architecture in JDK 1.2
Author(s): Lora Kassab and Steven Greenwald
E-mail Address:
Citation: Proceedings of the European Symposium on Research in Computer Security (ESORICS '98), Leuven-la-Neuve, Belgium: Springer LNCS, 191-207.
Date: September 1998
Report No: CHACS-98-012

Abstract
The Java security architecture in the Java Development Kit 1.2 expands the current Java sandbox model, allowing finer-grained, configurable access control for Java code. This new security architecture permits more precise, yet flexible, protection for both remote code (loaded across a network connection) and local code (residing on the same machine running the Java Virtual Machine) developed using the Java programming language. Our formal model and analysis is intended to: (1) allow designers and implementers to understand and correctly use the protection provided by these security controls, and (2) provide guidance to a JVM implementer wishing to support these security controls. Access control decisions in Java are made based on the current execution context using stack introspection. To model this, we employ a state-based model that uses multiple access control matrices to model the security controls in JDK 1.2. We also present a safety analysis and discuss the effects of static and dynamic security policies for a given Java Virtual Machine.

Title: Towards an Infrastructure for MLS Distributed Computing
Author(s): Myong H. Kang, Judith N. Froscher and Brian J. Eppinger
E-mail Address: mkang@itd.nrl.navy.mil, froscher@itd.nrl.navy.mil
Citation: Proceedings of the 14th Annual Computer Security Applications
    Conference, Scottsdale, AZ: IEEE Computer Society.
Date: 7-11 December 1998
Report No: CHACS-98-011

Abstract
Distributed computing owes its success to the development of infrastructure,
middleware, and standards (e.g., CORBA) by the computing industry. This
community has also recognized the need to protect information and has started to
develop commercial security infrastructures and standards. The US Government
must protect national security information against unauthorized information flow.
To support MLS distributed computing, a MLS infrastructure must be built that
enables information sharing among users at different classification levels. This
infrastructure should provide MLS services for protection of classified information
and use both the emerging distributed computing and commercial security
infrastructures. The resulting infrastructure will enable users to integrate
commercial information technology products into their systems.

In this paper, we examine the philosophy that has led to successful distributed
computing among heterogeneous, autonomous components and propose an
analogous approach for MLS distributed computing. We identify some services that
are required to support MLS distributed computing, argue that these services are
needed regardless of the MLS architecture used, present an approach for designing
these services, and provide design guidance for a critical building block of the MLS
infrastructure.

Title: Using Abstraction and Model Checking to Detect Safety Violations in
    Requirements Specifications
Author(s): Constance L. Heitmeyer, James C. Kirby, Jr., Bruce Labaw, Myla M.
    Archer and Ramesh Bharadwaj
E-mail Address: heitmeyer@itd.nrl.nav.mil, kirby@itd.nrl.navy.mil,
    archer@itd.nrl.navy.mil, ramesh@itd.nrl.navy.mil
Citation: IEEE Transactions on Software Engineering **24**, no. 11: 927-948.
Date: November 1998
Report No: CHACS-98-008

Abstract
Exposing inconsistencies can uncover many defects in software specifications. One
approach to exposing inconsistencies analyzes two redundant specifications, one
operational and the other property-based, and reports discrepancies. This paper
describes a "practical" formal method, based on this approach and the SCR
(Software Cost Reduction) tabular notation, that can expose inconsistencies in
software requirements specifications. Because users of the method do not need
advanced mathematical training or theorem proving skills, most software
developers should be able to apply the method without extraordinary effort. This
paper also describes an application of the method which exposed a safety violation
in the contractor-produced software requirements specification of a sizable, safety-

critical control system. Because the enormous state space of specifications of practical software usually renders direct analysis impractical, a common approach is to apply abstraction to the specification. To reduce the state space of the control system specification, two "pushbutton" abstraction methods were applied, one which automatically removes irrelevant variables and a second which replaces the large, possibly infinite, type sets of certain variables with smaller type sets. Analyzing the reduced specification with the model checker Spin uncovered a possible safety violation. Simulation demonstrated that the safety violation was not spurious but an actual defect in the original specification.

Title: Using the NRL Protocol Analyzer to Analyze Protocol Suites
Author(s): Catherine Meadows
E-Mail Address: meadows@itd.nrl.navy.mil
Citation: Proceedings of the Logic in Computer Science Workshop on Formal
    Methods and Security Protocols, Indianapolis, IN: Bell Laboratories.
    <http://www.cs.bell-labs.com/who/nch/fmsp/index.html>
Date: 25 June 1998
Report No.: Not assigned

Abstract
In This paper we discuss the application of the NRL Protocol Analyzer, a special-purpose formal methods tool designed for the verification of cryptographic protocols, to the analysis of suites of related security protocols. We describe the challenges proposed by this problem, and we describe the modifications we made to the NRL Protocol Analyzer to deal with it. These modifications also had the advantage of making the NRL Protocol Analyzer much easier to use. We also describe the use of the Analyzer in our ongoing verification of the IKE protocol, and describe some of the results we found.

Title: Using the SCR* Toolset to Specify Software Requirements.
Author(s): Constance L. Heitmeyer
E-mail Address: heitmeyer@itd.nrl.navy.mil
Citation: Proceedings of the Second IEEE Workshop on Industrial Strength Formal
    Specification Techniques (WIFT'98), Boca Raton, FL: IEEE, 12-13.
Date: 19 October 1998
Report No: CHACS-98-007

Abstract
Formulated in the late 1970s to specify the requirements of the Operational Flight Program (OFP) of the A-7 aircraft, the SCR (Software Cost Reduction) requirements method is a method based on tables for specifying the requirements of software systems. During the 1980s and the early 1990s, many companies, including Bell Laboratories, Grumman, Ontario Hydro, and Lockheed, applied the SCR requirements method to practical systems. Each of these applications of SCR had, at most, weak tool support. To provide powerful, robust tool support customized for the SCR method, we have developed the SCR* toolset. To provide formal underpinnings for the method, we have also developed a formal model which defines the semantics of SCR requirements specifications.

Title: Weakly Secret Bit Commitment: Applications to Lotteries and Fair Exchange
Author(s): Paul F. Syverson
E-mail Address: syverson@itd.nrl.navy.mil
Citation: Proceedings of the 1998 IEEE Computer Security Foundations Workshop (CSFW11), Rockport, MA: IEEE, 2-13.
Date: June 1998
Report No: CHACS-98-020

Abstract
This paper presents applications of weak cryptography for which weakness is not just acceptable but desirable. For one application, several versions of a lottery scheme are presented in which the result of the lottery is determined by the ticket numbers purchased, but no one can control the outcome or determine what it is until after the lottery closes. This is because the outcome is kept secret in a way that is breakable after a predictable amount of time and/or computation. Another presented application is a form of fair exchange protocols that requires no trusted third party at all.

1997 PUBLICATIONS

CHACS-97-001
Human-Style Theorem Proving Using PVS; Myla M. Archer and Constance L. Heitmeyer

CHACS-97-003
Verifying SCR Requirements Specifications using State Exploration; Ramesh Bharadwaj and Constance L. Heitmeyer

CHACS-97-005
Model Checking Complete Requirements Specifications Using Abstraction; Ramesh Bharadwaj and Constance L. Heitmeyer

CHACS-97-007
Design and Assurance Strategy for the NRL Pump; Myong H. Kang, Andrew P. Moore and Ira S. Moskowitz

CHACS-97-008
The JMCIS Information Flow Improvement (JIFI) Assurance Strategy; Andrew P. Moore

CHACS-97-009
Unlinkable Serial Transactions; Paul F. Syverson, Stuart G. Stubblebine and David M. Goldschlag

CHACS-97-010
Mobile Ad Hoc Networking (MANET): Routing Protocol Performance and Evaluation Considerations; Joseph Macker and M. Scott Corson

CHACS-97-011
Reliable Multicast Transport and Integrated Erasure-Based Forward Error Correction; Joseph Macker

CHACS-97-012
Controlled Link Sharing and Reliable Multicast for Asymmetric Networks; Joseph Macker and M. Scott Corson

CHACS-97-013
Practical Defenses Against Storage Jamming; J. McDermott and Judith N. Froscher

CHACS-97-014
Rigorous Requirements for Real-Time Systems: Evolution and Application of the SCR Method; Stuart Faulk and Constance Heitmeyer

CHACS-97-015
Verifying SCR Requirements Specifications Using State Exploration; Ramesh Bharadwaj and Constance Heitmeyer

CHACS-97-016
Verifying Hybrid Systems Modeled as Timed Automata: A Case Study, in Hybrid and Real-Time Systems; Myla Archer and Constance Heitmeyer

CHACS-97-017
Formal Methods for Real-Time Computing: A Panacea or Academic Poppycock; Constance Heitmeyer

CHACS-97-018
Rigorous Requirements for Real-Time Systems: Evolution and Application of the SCR Method; Stuart Faulk and Constance Heitmeyer

CHACS-97-019
The SCR Method for Specifying, Verifying and Validating Requirements; Constance Heitmeyer, James Kirby and Bruce Labaw

CHACS-97-020
Tools for Formal Specification, Verification and Validation of Requirements; Constance Heitmeyer, James Kirby and Bruce Labaw

CHACS-97-021
A Flexible, Extensible Simulation Environment for Testing Real-Time Specifications; Brockmeyer, Monica, Farnam Jahanian, Constance Heitmeyer and Bruce Labaw

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Applying the SCR Requirements Method to a Simple Autopilot; Ramesh Bharadwaj and Constance Heitmeyer

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Replication Does Survive Information Warfare Attacks; John McDermott

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Reducing Uncertainty About Common-Mode Failures; J. Voas, J., A. Ghosh, L. Kassab and F. Charron

CHACS-97-028
Simulating Specification Errors and Ambiguities in Systems Employing Diversity; J. Voas and L. Kassab

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Protocols using Anonymous Connections: Mobile Applications; M. G. Reed, Paul Syverson and David M. Goldschlag

CHACS-97-030
An Insecurity Model; I. S. Moskowitz and M. H. Kang

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Protecting Unattended Computers Without Software; Carl E. Landwehr

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Security Issues in Networks with Internet Access; C. E. Landwehr and David M. Goldschlag

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Safe Use of the Internet for Defence Purposes. TTCP STP-11 Report; Carl E. Landwehr et al.

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Private Web Browsing; Paul F. Syverson, Michael G. Reed and David M. Goldschlag

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Privacy on the Internet; David M. Goldschlag, Michael G. Reed, and Paul F. Syverson

CHACS-97-036
Internet Communication Resistant to Traffic Analysis; David M. Goldschlag, Michael G. Reed and Paul F. Syverson

CHACS-97-037
Anonymous Connections and Onion Routing; Michael G. Reed, Paul F. Syverson and David M. Goldschlag

CHACS-97-038
A Client-Server Architecture Supporting MLS Interoperability with COTS Components; J. N. Froscher and M. H. Kang

CHACS-97-039
Design and Assurance Strategy for the NRL Pump; M. H. Kang, J. N. Froscher and I. S. Moskowitz

CHACS-97-040
A Different Look at Secure Distributed Computation; Paul F. Syverson

CHACS-97-041
On Searching for Known and Chosen Cipher Pairs Using the NRL Protocol Analyzer; Stuart G. Stubblebine and Catherine A. Meadows

CHACS-97-042
Detecting Attacks on Mobile Agents; Catherine A. Meadows

CHACS-97-043
Three Paradigms in Computer Security; Catherine A. Meadows

CHACS-97-044
Critical Analysis of Security in Voice Hiding Techniques; L. Chang and I. Moskowitz

CHACS-97-045
An Architecture for Multilevel Secure Interoperability; M. H. Kang, J. N. Froscher and I. S. Moskowitz

CHACS-97-046
Protection (Security) Models and Policy; C. E. Landwehr

CHACS-97-047
Computer Security, the Good, the Bad, and the Ugly; Catherine Meadows

CHACS-97-048
Panel: What Protocol Designers Need From Formal Methods; Catherine Meadows

CHACS-97-049
Panel on Languages for Formal Specification of Security Protocols; Catherine Meadows

CHACS-97-050
Reducing the Risk of Multi-Level Secure (MLS) Workstations; J. Eric Klinker and David M. Mihelcic
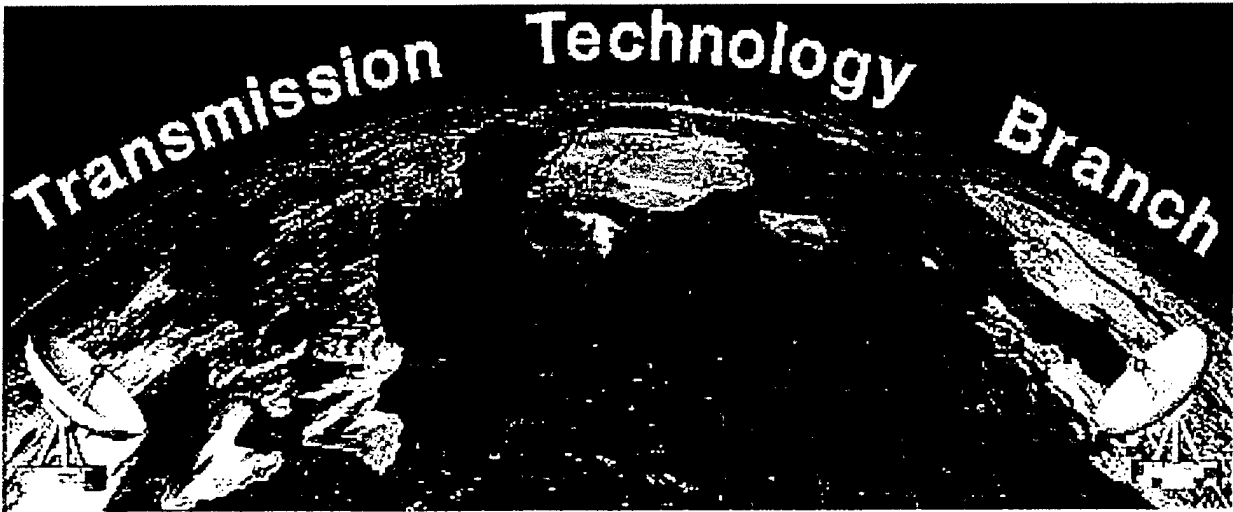
CHACS-97-051
A Thread-Local Storage Class for Win32; Bruce Montrose

CHACS-97-052
Architecture and Components for Data Management Security: NRL Perspective; C. E. Landwehr and J. N. Froscher

CHACS-97-053
Replay and Replication Defenses Against Storage Jamming; J.P. McDermott and J. N. Froscher

T he Transmission Technology (TT) Branch conducts a research and development program directed toward the improvement of information transmission and reception between surface, air, submerged and space platforms. The Branch mission includes understanding and developing approaches to satisfy the need for affordable, efficient and robust dissemination of combat management information In support of this goal, the Branch investigates all aspects of the process of information transfer including the development of state-of-the-art transmission equipment as well as research into antennas and channel propagation phenomena.

E mphasis is placed on those aspects of transmission technology that permit adaptation to inhospitable natural or man-made environments. In addition, the Branch conducts research and development in support of signal intercept and related intelligence system projects. Areas of activity include: (1) wideband HF architecture and RF system engineering; (2) communication channel characterization including Arctic communication issues; (3) intercept system analysis, development and prototype evaluation; (4) satellite and space communication technology; an (5) research into wideband and compact antenna systems.

TRANSMISSION TECHNOLOGY
Code 5550

Title: Boeing Site Visit by N6 Team Antenna
Author(s): John B. Wood
E-Mail Address: wood@itd.nrl.navy.mil
Citation: NRL Technical Memorandum 5550-064.
Date: 26 May 1998
Report No.: Not assigned

This report has no abstract.

Title: Harris Site Visit by N6 Team Antenna
Author(s): John B. Wood
E-Mail Address: wood@itd.nrl.navy.mil
Citation: NRL Technical Memorandum 5550-079.
Date: 23 June 1998
Report No.: Not assigned

This report has no abstract.

Title: High Frequency Active Auroral Research Program
Author(s): Edward J. Kennedy, Paul Kossey, John Heckscher and H. C. Carlson
E-mail Address: kennedy@itd.nrl.navy.mil
Citation: Arctic Research of the United States, National Science Foundation **13** :
   National Science Foundation.
Date: Fall/Winter 1998
Report No.: Not assigned

This report has no abstract.

Title: Probing Space Plasmas Using the New HAARP Ionospheric Heater
Author(s): P. Rodriguez, M. Keskinen and Edward J. Kennedy
E-Mail Address: kennedy@itd.nrl.navy.mil
Citation: 1998 NRL Review, NRL Publication NRL/PU/5230--98-350, Washington:
   Naval Research Laboratory, 151-154.
Date: April 1998
Report No.: Not assigned

This report has no abstract.

Title: Proposal for a Definitive Naval Platform Antenna Study
Author(s): John B. Wood
E-Mail Address: wood@itd.nrl.navy.mil
Citation: NRL Transmission Technology Branch Proposal.
Date: 30 June 1998
Report No.: Not assigned

This report has no abstract.

Title: Speech Enhancement for Bandlimited Speech
Author(s): David A. Heide and George S. Kang
E-Mail Address: heide@itd.nrl.navy.mil, kang@itd.nrl.navy.mil
Citation: Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing, Seattle, WA: IEEE, 393-396.
Date: May 1998
Report No.: Not assigned

Abstract
Throughout the history of telecommunication, speech has rarely been transmitted with its full analog bandwidth (0 to 8 kHz or more) due to limitations in channel bandwidth. This impaired legacy continues with tactical voice communication. The passband of a voice terminal is typically 0 to 4 kHz. Hence, high-frequency speech components (4 to 8 kHz) are removed prior to transmission. As a result, speech intelligibility suffers, particularly for low-data-rate vocoders. In this paper, we describe our speech-processing technique, which permits some of the upperband speech components to be translated into the passband of the vocoder. According to our test results, speech intelligibility is improved by as much as three to four points even for the recently developed and excellent Department of Defense-standard Mixed Excitation Linear Predictor (MELP) 2.4 kb/s vocoder. Note that speech intelligibility is improved without expanding the transmission bandwidth or compromising interoperability with others.

Title: Speech Enhancement in Noise and Within Face Mask (Microphone Array Approach)
Author(s): George S. Kang and Thomas M. Moran
E-Mail Address: kang@itd.nrl.navy.mil, moran@itd.nrl.navy.mil
Citation: Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing, Seattle, WA: IEEE, 1017-1020.
Date: May 1998
Report No.: Not assigned

Abstract
In certain communication environments, digital speech transmission systems must work in severe acoustic environments where the noise levels exceeds 110 dB. In other environments, speakers must use an oxygen face mask. In both situations, the intelligibility of encoded speech falls below an acceptable level. We have developed a technique for improving speech quality in these situations.

Previous speech improvement methods have focused on processing the corrupted signal after it has been induced by the microphone. These methods have not

performed adequately. In our technique, speech anomalies are attenuated by a microphone array before speech and noise become mixed into a signal.

Our microphone array prototype has shown excellent performance. In an example of speech taken aboard an E2C aircraft, this noise-canceling microphone array improved the speech-to-noise ratio by as much as 18 dB. When the same technique is used in a face mask, muffled speech was almost completely restored to high quality speech.

Title: The WIND-HAARP Experiment: Initial Results of High Power Radiowave Interactions with Space Plasmas

Author(s): P. Rodriguez, Edward J. Kennedy, M. J. Keskinen, C. L. Siefring, Sa. Basu, M. McCarrick, J. Preston, M. Engebretson, M. L. Kaiser, M. D. Desch, K. Goetz, J.-L. Bougeret, and R. Manning

E-Mail Address: kennedy@itd.nrl.navy.mil

Abstract

Results from the first science experiment with the new HF Active Auroral Research Program (HAARP) in Alaska are reported. The objective was to study the effects of space plasmas on high power radiowave transmission to high altitudes in the magnetosphere. Reception was done by the NASA/WIND satellite. The data suggest that structured space plasmas along the propagation path impose a power law spectrum of fluctuations on the transmitted waves, resembling scintillations. Because the transmitted waves are near ionospheric plasma frequencies, other types of wave plasma interactions may occur. Such measurements can provide a new diagnostic tool.

1997 PUBLICATIONS

TT-97-001

Demonstration of High Data Rate and Medium Data Rate VSAT Communications using the Global Broadcast System (GBS) Transponder; M. Rupar, T. Krout and A. Eley

TT-97-002

Theoretical and Experimental Investigation of the Impedance of a Vertical Monopole over Perfect, Imperfect, and Enhanced Ground Planes; Michael A. Rupar

TT-97-003

Voice Processing Techniques for C4I Applications; G. S. Kang, L. J. Fransen, T. M. Moran and D.A. Heide

TT-97-004

High Data Rate Very Small Aperture Terminal Networking in Support of the New Attack Submarine; LCDR Jeffrey L. Benson, Timothy L. Krout, Michael A. Rupar and Mark H. Solsman

The Advanced Information Technology (AIT) Branch of the Information Technology Division develops and implements cutting edge hardware and software solutions to Navy problems in a number of application areas. Current research and development thrusts include:

- parallel and distributed hardware, software and display technololgies;

- novel signal processing techniques directed primarily toward the exploitation of massively parallel systems;

- development of hardware-independent systems for developing and porting code for parallel processing systems;

- design and implementation of reactive and interactive control systems;

- development of technologies for decision support systems and prototyping of all varieties of decision systems including tactical decision aides and mission planning;

- exploration and demonstration of new methods for data management including data fusion, design and navigation of database systems, and correlation and

tracking of current and historical information; and display technologies for visual management of all of the above applications.

The technical programs in the Branch include some basic research (6.1), a substantial exploratory development program (6.2), and a continuing effort to field technology through a succession of advanced technology demonstrations (6.3a). The Branch draws on expertise in computer science, mathematics, operations research, electrical engineering, and physics.

ADVANCED INFORMATION TECHNOLOGY
Code 5580

Title: Advanced Processing Technology
Author(s): Wendell L. Anderson, Haw-Jye Shyu and William R. Smith
E-Mail Address: shyu@ait.nrl.navy.mil, smith@ait.nrl.navy.mil
Citation: FY97 High Performance Computing (HPC) Modernization Program Report, NRL Publication NRL/PU/5590--98-355, Washington: Naval Research Laboratory.
Date: April 1998
Report No.: AIT-98-033

Abstract
The emphasis in antisubmarine warfare operations has moved from the detection and localization of targets in deep water and over long ranges to the detection, localization, and tracking of targets in shallow water and over short ranges. This problem has been complicated in littoral areas by the quieting of the target and high levels of congestion and clutter. The complexity of the problem requires the use of computationally intensive algorithms to process data from the full spectrum of signals available from ocean deployed sensors. The objective of this research is to assess the applicability of High Performance Computers to these algorithms ad to investigate the exploitability of broadband energy sources for use in Naval warfare operations.

Title: Application of the Bearing Trace Hough Transform (BTHT) for Passive Shipping Lane Monitoring
Author(s): Haw-Jye Shyu and Yung P. Lee
E-Mail Address: shyu@ait.nrl.navy.mil
Citation: NRL Formal Report NRL/FR/5580--98-9877, Washington: Naval Research Laboratory.
Date: 30 January 1998
Report No.: AIT-98-006

Abstract
A modified Hough transform to detect targets on SONAR B-scan produced from data collected by a passive acoustic sensor array is presented. Assuming that the target maintains a constant course and speed during the observation period, the target trace on the passive SONAR B-scan can be shown as an arctangent function defined by the following target track parameters: (1) speed, (2) course, (3) range at the Closest Point of Approach (CPA), and (4) CPA time. Detection of the target traces on the SONAR B-scan can then be formulated as detection of the arctangent curves using the modified Hough transform. The track parameters of the target can be estimated and used to identify different targets.

Title: Applying the Delay Curve Hough Transform to Shallow Water Environments
Author(s): Haw-Jye Shyu and Wendell L. Anderson
E-Mail Address: shyu@ait.nrl.navy.mil
Citation: NRL Formal Report NRL/FR/5580--98-9888, Washington: Naval Research Laboratory.
Date: 9 September 1998
Report No.: AIT-98-015

Abstract

The Delay Curve Hough Transform (DCHT) has been proposed to detect the traces produced by constant velocity targets in broadband correlograms and to estimate target track parameters. The derivation of the DCHT assumed that the sound velocity profile is a constant and the correlation trace is due to the direct propagation path. These assumptions are not true in shallow water environments. This study investigates the use of the DCHT in these environments by examining the effects of the Sound Velocity Profile on the correlation traces appearing in broadband correlograms for three different shallow water environments. The GAMARAY model, an eigenray based sound propagation model, was used to produce the sound field. Even though beyond some short ranges, the direct propagation path disappears and the dominant eigenrays are due to multipath, the correlation traces still maintain the shape of the analytic delay curves, and the DCHT successfully detects the targets. The estimates of target heading, speed factor, and CPA time by the DCHT proved to be accurate. However, in most cases, estimates of the depth factor were incorrect. A theoretical explanation for the unreliability of the estimation of the depth factor is also given.

Title: Battlefield Visualization on the Responsive Workbench
Author(s): Jim Durbin, J. Edward Swan II, Brad Colbert, John Crowe, Rob King, Tony King, Chris Scannell, Zachary Wartell and Terry Welsh
E-Mail Address: swan@ait.nrl.navy.mil, scannell@ait.nrl.navy.mil
Citation: Proceedings of the IEEE Visualization 98, Research Triangle Park, NC: IEEE, 463-466.
Date: 18-23 October 1998
Report No.: AIT-98-019

Abstract

In this paper we describe a Battlefield Visualization system, called Dragon, which we have implemented on a Virtual Reality Responsive Workbench. The Dragon system has been successfully deployed as part of two large military exercises - Hunter Warrior Advanced Warfighting Experiment (AWE), in March 1997, and Joint Counter Mine (JCM) Advanced Concept Tactical Demonstration (ACTD), in August and September 1997. We describe the Dragon system and the workbench, and we describe our experiences as part of these two real-world deployments, with an emphasis on lessons learned and needed future work.

Title: An Efficient Algorithm for Computing Least Cost Paths with Turn Constraints
Author(s): Ali Boroujerdi and Jeffrey K. Uhlmann
E-Mail Address: boroujerdi@ait.nrl.navy.mil, uhlmann@ait.nrl.navy.mil
Citation: Information Processing Letters Journal **67**, no. 6: 317-321.
Date: 30 September 1998
Report No.: AIT-98-008

Abstract

An Algorithm is presented for computing least cost paths under turn angle constraints. The approach is almost as efficient as Dijkstra's algorithm for unconstrained least cost paths. Specifically, if a graph representation of a two or three dimensional routing problem contains $|v|$ vertices and $|E|$ edges, then our algorithm scales as $0 (|E| \log |v|$ versus the $O (|v| \log |v| + |E|)$ complexity for the most efficient implementation of Dijkstra's algorithm. This result is substantially better than $O (O|E||v|)$ algorithms for the more general problem of routing with turn penalties, which cannot be applied to large-scale graphs.

Title: Empirical Analysis of New Methods for Computing Minimum Cost Paths with Turn Constraints
Author(s): Ali Boroujerdi and Jeffrey Uhlmann
E-Mail Address: boroujerdi@ait.nrl.navy.mil, uhlmann@ait.nrl.navy.mi.
Citation: Proceedings of the International Society for Optical Engineering (SPIE) Conference on Robotic and Semi-Robotic Ground Vehicle Technology, Vol. 3366, Orlando, FL: SPIE, 262-272.
Date: 13-17 April 1998
Report No.: AIT-98-013

Abstract

In this paper we describe a recently developed algorithm for computing least cost paths under turn angle constraints. If a graph representation of a two or three-dimensional routing problem contains $|V|$ vertices and $|E|$ edges, then the new algorithm scales as $O(|E|\log|V|)$. This result is substantially better than $O(|E||V|)$ algorithms for the more general problem of routing with turn penalties, which cannot be applied to large-scale graphs. We also describe an enhancement to the new algorithm that dramatically improves the performance in practice. We provide empirical results showing that the new algorithm can substantially reduce the computation time required for constrained vehicle routing. This performance is sufficient to allow for the dynamic re-routing of vehicles in uncertain or changing environments.

Title: Event Distribution and State Sharing In the Thema Parallel Discrete Event
Simulation Modeling Framework
Author(s): Henry Ng, Darrin West, David Itkin and James Ramsey
E-Mail Address: ng@ait.nrl.navy.mil
Citation: Proceedings of the Object Oriented Simulation Conference (OOS'98), San
Diego, CA: Society for Computer Simulations, 24-29.
Date: 11-14 January 1998
Report No.: AIT-98-002

Abstract

Combat models require access to shared state such as entity position data and to
exchange area effect events such as detonations. While traditional Parallel Discrete
Event Simulation has a point to point communication paradigm, point to multipoint
solutions are more efficient for this problem. We have developed a simulation
framework called Thema which addresses these issues while providing transparent
access to parallelism and type safe exchange of events and data between entities.
Thema is targeted to small inexpensive multiprocessor machines and clusters, and
uses the SAIC developed Time Warp kernal Tempo.

Title: Grotto Visualization for Decision Support
Author(s): Marco Lanzagorta, Eddy Kuo and Jeffrey Uhlmann
E-Mail Address: uhlmann@ait.nrl.navy.mil
Citation: Proceedings of the International Society for Optical Engineering (SPIE)
International Symposium on Aerospace/Defense Sensing, Simulation, and
Controls (AeroSense), Vol. 3366, Orlando, FL: SPIE, 165-176.
Date: 13-17 April 1998
Report No.: AIT-98-018

Abstract

In this paper we describe the GROTTO (Graphical Room for Observation, Tactical
Training and Orientation) visualization projects being carried out at the Naval
Research Laboratory. GROTTO is a CAVE-like system, that is, a surround-screen,
surround sound, immersive virtual reality device. We have explored the GROTTO
visualization in a variety of scientific areas including oceanography, meteorology,
chemistry, biochemistry, computational fluid dynamics and space sciences.
Research has emphasized the applications of GROTTO visualization for military,
land and sea-based command and control. Examples include the visualization of
ocean current models for the simulation and study of mine drifting and, inside our
computational steering project, the effects of electromagnetic radiation on missile
defense satellites. We discuss plans to apply this technology to decision support
applications involving the deployment of autonomous vehicles into contaminated
battlefield environments.

Title: HPC Prototyping of PGMT (Processing Graph Method Tool) Application
   Programming Interfaces
Author(s): Roger Hillson
E-Mail Address: hillson@ait.nrl.navy.mil
Citation: FY97 High Performance Computing (HPC) Modernization Program Report,
   NRL Publication NRL/PU/5590--98-355, Washington: Naval Research Laboratory.
Date: April 1998
Report No.: AIT-98-034

Abstract
This work supports the development of the Processing Graph Method Tool (PGMT).
The Processing Graph Method (PGM), which was invented and refined at NRL, is a
draft IEEE-standard data-flow method for programming networks of processors.
PGMT is a software tool designed to reduce the time required to implement PGM on
a relatively arbitrary network of parallel processors from approximately 50 man-
years to approximately 5 man-years.

Title: HPC Strike Support with SPEEDES/NSS
Author(s): William Smith and Roger Hillson
E-Mail Address: smith@ait.nrl.navy.mil , hillson@ait.nrl.navy.mil
Citation: FY97 High Performance Computing (HPC) Modernization Program Report,
NRL Publication NRL/PU/5590--98-355, Washington: Naval Research Laboratory.
Date: 1 April 1998
Report No.: AIT-98-038

Abstract
This work is in support of HPCMO CHSSI Project FMS-3. The objective is to
substantially reduce execution time for strike warfare discrete-event simulation
systems via parallel optimistic scheduling techniques running on HPC assets. The
targeted simulation system is a Navy warfare simulation capability called NSS
(Naval Simulation System). Through high performance parallel computing, NSS and
other warfare simulation systems may be made to execute in near real-time and
thus have direct operational utility.

Title: Identification of Distant Ship Smokestack Insignia
Author(s): Behzad Kamgar-Parsi, T.C. Zenner, Behrooz Kamgar-Parsi, J. C.
   Sciortino and A. Khan
E-Mail Address: behzad@ait.nrl.navy.mil, kamgar@aic.nrl.navy.mil
Citation: 1998 NRL Review, NRL Publication NRL/PU/5230--98-350, Washington:
   Naval Research Laboratory, 129-131.
Date: April 1998
Report No.: AIT-98-039

Abstract
Monitoring surface ship traffic is a problem of considerable interest to the Navy,
international regulatory agencies, insurance companies, etc. This problem is being
pursued in different ways, such as radar signature identification, smokestack
insignia recognition, superstructure shape identification, etc., by different Navy
organizations, including NRL. A joint effort by the Information Technology and the
Tactical Electronic Warfare Divisions of NRL has resulted in considerable progress in
solving the challenging problem of smokestack insignia identification. The problem

requires finding the best match to the encountered insignia in the database of registered shipping line insignias, and deciding whether the match is correct. The database of registered insignias, despite its huge size (several thousand items), is incomplete. The problem is further complicated if the extracted insignia (from an image background) is degraded by its distance and other factors, as well as the existence of discrepancies among individual insignias representing the same shipping line. A distant target is typically subject to blurring, noise, and other distortions, so that when it is matched to database items it may turn out to be less similar to its own ideal model than another database item. To reduce the likelihood of such misidentifications, we have developed an approach where the database is enlarged to include appropriately degraded versions of the ideal multicolor items in the original database. The extracted target is likely to match closely one of the distorted versions of its corresponding database items. Furthermore, we have developed a technique on how the database insignias, as well as the extracted insignias, are processed and indexed; this allows an efficient search for finding the best match.

Title: Identification of Distant Targets In A Visual Database
Author(s): Behzad Kamgar-Parsi, Todd C. Zenner, Behrooz Kamgar-Parsi, John C. Sciortino and Abdul Khan
E-Mail Address: behzad@ait.nrl.navy.mil, kamgar@aic.nrl.navy.mil
Citation: Proceedings of the International Society for Optical Engineering (SPIE) Conference on Automatic Target Recognition, Vol. 3371, Orlando, FL: SPIE, 346-353.
Date: April 1998
Report No.: AIT-98-001

Abstract

Searching a large visual database for the item(s) most similar to a test object is a tedious task that has many applications. This task is further complicated if the test object (extracted from an image) is degraded by its distance and other factors. A distant target is typically subject to blurring, noise, and other distortions, so that when it is matched to database items it may turn out to be less similar to its own ideal model than another database item. As an example we discuss the problem of ship identification from the smokestack insignia, i.e., extracting the ship's insignia from its color photo and finding its closest matches in a database containing thousands of registered shipping line insignias. This is a problem of interest to international regulatory agencies, insurance companies and others. We discuss how the database insignias, as well as the extracted insignias, are processed and indexed, and how the distorted version of ideal insignias are generated.

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Abstract

Three dimensional (3D) visualization and interaction play an important role in
understanding the complexities of, and relationships in, an environment. The
ability to effectively interact with the environment being modeled, in turn, depends
on the user interface. Historically, desktop displays have been used for
visualization using a mouse/menu user interface. The Naval Research Laboratory
(NRL) has been exploring 3D visualization and interface technologies for a display
system called the Virtual Reality Responsive WorkBench (VRRWB). The VRRWB is a
table top display, which was originally designed and developed at the German
National Research Center. The total display area is approximately 3 feet in depth
and 5 feet in length. A similar VRRWB was fabricated at the NRL and currently a
commercial version is being utilized in which the table top can be tilted slightly for
easier viewing. The workbench configuration consists of a translucent table top and
projector. Video from a projector is directed towards a front surface mirror tilted at a
45-degree angle under the translucent table. This video is relected onto the table
top. The workbench allows users to interact with objects in a more natural setting,
as it provides the capability to view and interact with objects that fit within a table
top paradigm. In addition, it provides a greater viewing area, allowing multiple
participants to more easily view/interact with the environment being modeled.
Additionally, objects can be displayed on the workbench in stereographics mode,
allowing them to appear as if floating above or lying underneath the table top. In
this way, viewing depth is made easier.

A particular application that has been enhanced for the VRRWB is the Strike
Optimized Mission Planning Module (STOMPM) testbed developed at NRL. The
STOMPM testbed serves as a focal point for research in path optimization
algorithms for strike assets, 3D visualization/user interfaces, and collaborative
decision making, all in the context strike planning. This paper will concentrate on
the details of STOMPM with regard to 3D visualization and user interfaces
specifically for the workbench, showing how this interface is more suited to the
workbench than to a mouse/menu style interface. The paper will be organized as
follows: We will begin by briefly discussing the nature of the STOMPM testbed,
listing design considerations. Next we will provide an in-depth rationale for the
interface that has been developed within STOMPM for the VRRWB. The paper will
conclude with a brief discussion of future research, particularly with regard to
developing user interfaces for immersive display/computing environments such as
the CAVE™ and integrating with non- and semi-immersive display/computing
environments (i.e., VRRWB) in order to realize a distributed, collaborative,
computing, and visualization environment.

Title: Making Information Overload Work: The Dragon Software System on a Virtual Reality Workbench

Author(s): James Durbin, Simon Julier, Brad Colbert, John Crowe, Rob King, Christopher Scannell, Zackary Justin Wartell and Terry Welsh

E-Mail Address: scannell@ait.nrl.navy.mil

Citation: Proceedings of the International Society for Optical Engineering (SPIE) International Symposium on Aerospace/Defense Sensing, Simulation, and Controls (AeroSense), Vol. 3393, Orlando, FL: SPIE, 96-107.

Date: 13-17 April 1998

Report No.: AIT-98-014

Abstract

Gaining a detailed and thorough understanding of the modern battlespace is vital to the success of any military operation. Military commanders have access to significant quantities of information, which originate from disparate and occasionally conflicting sources and systems. Combining this information into a single, coherent view of the environment can be extremely difficult, error prone and time consuming.

In this paper we describe the Naval Research Laboratory's Virtual Reality Responsive Workbench (VRRWB) and Dragon software system which together address the problem of battlespace visualization. The VRRWB is a stereoscopic 3D interactive graphics system, which allows multiple participants to interact in a shared virtual environment and physical space. A graphical representation of the battlespace, including the terrain and military assets, which lie on it, is displayed on a projection table. Using a six degree of freedom tracked joystick; the user navigates through the environment and interacts, via selection and querying, with the represented assets and the terrain.

The system has been successfully deployed in the Hunter Warrior Advanced Warfighting Exercise and the Joint Countermine ACTD Demonstration One. In this paper we describe the system and its capabilities in detail, discuss its performance in these two operations, and describe the lessons, which have been learned.

Title: Quantization Error in Regular Grids: Triangular Pixels

Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-Parsi

E-Mail Address: kamgar@aic.nrl.navy.mil, behzad@ait.nrl.navy.mil

Citation: IEEE Transactions on Image Processing **7**, No. 10: 1496-1500.

Date: October 1998

Report No.: Not assigned

Abstract

Quantization of the image plane into pixels results in the loss of the true location of features within pixels and introduces an error in any quantity computed from feature positions in the image. Here we derive closed-form, analytic expressions for the error distribution function, the mean absolute error (MAE), and the mean square error due to triangular tessellation, for differentiable functions of an arbitrary number of independently quantized points, using a linear approximation of the function. These quantities are essential in examining the intrinsic sensitivity of image processing algorithms. Square and hexagonal pixels were treated in previous papers.

Title: Routing and Advanced Display Technologies within STOMPM

Author(s): Ranjeev Mittu, Jeffrey Uhlmann and Justin McCune
E-Mail Address: mittu@ait.nrl.navy.mil and uhlmann@ait.nrl.navy.mil

Abstract

This paper will discuss research conducted at the Naval Research Laboratory (NRL) in the area of ground and air platform routing, advanced 3D displays and novel interface techniques for interacting with those displays. This research has culminated in the development of the Strike Optimized Mission Planning Module (STOMPM), which is a flexible research testbed incorporating advances in each of the aforementioned areas.

Title: Splatting Errors and Antialiasing

Author(s): Klaus Mueller, Torsten Möller, J. Edward Swan II, Roger Crawfis, Naeem Shareef and Roni Yagel
E-Mail Address: swan@ait.nrl.navy.mil

Abstract

This paper describes three new results for volume rendering algorithms utilizing splatting. First, an antialiasing extension to the basic splatting algorithm is introduced that mitigates the spatial aliasing for high-resolution volumes. Aliasing can be severe for high-resolution volumes or volumes where a high depth of field leads to converging samples along the perspective axis. Next, an analysis of the common approximation errors in the splatting process for perspective viewing is presented. In this context, we give different implementations, distinguished by efficiency and accuracy, for adding the splat contributions to the image plane. We then present new results in controlling the splatting errors and also show their behavior in the framework of our new antialiasing technique. Finally, current work in progress on extensions to splatting for temporal antialiasing is demonstrated. Here, we present simple but highly effective scheme for adding motion blur to fast moving volumes.

Title: Surveillance Planning Resource Optimization Using Non-linear Data Fusion
Author(s): James B. Hofmann and Ray H. Jakobovits
E-Mail Address:
Citation: Hamid R. Arabnia and Daniel Zhu (eds.), Proceedings of the First
    International Conference on Multisource-Multisensor Data Fusion (Fusion 98),
    Las Vegas, NV: CSREA Press, 733-740.
Date: 6-9 July 1998
Report No.: AIT-98-023

Abstract
An approach to surveillance planning resource optimization based on the no-detection likelihood forecasting features of an associated data fusion algorithm is described. Assuming a low signal-to-noise ratio in the data, the approach focuses on the assignment of processing assets available to a surveillance commander. Generic functions of a hypothetical Surveillance Center are described along with a set of decision aid algorithms for data fusion and resource optimization. The resource optimization model is described in detail along with several approaches to solving the optimization. Considerations regarding processing resources available and mobile vs. fixed sensors are also explored. The work is based on previously unpublished results obtained in a U. S. Navy sponsored undersea surveillance Advanced Technology Demonstration (1993).

Title: Theoretical Analysis of Scintillating Lossy Waveguides
Author(s): Dennis B. Creamer
E-Mail Address: creamer@ait.nrl.navy.mil
Citation: Proceedings of the International Conference on Shallow-Water Acoustics
    (SWAC 97), Beijing, China: China Ocean Press, 241-246.
Date: 21-25 April 1997
Report No.: AIT-98-009

Abstract
The behavior of acoustical fields in lossy shallow water waveguides is theoretically analyzed. The interplay between random sound speed inhomogeneities and subbottom acoustic attenuation (mode stripping) is studied with the aim of abstracting qualitative phenomena, e.g. acoustic intermittency. Our main research tool will be the use of stochastic coupled-mode theory. While other approaches (such as FEPE or UMPE) may be more useful for modeling realistic environments, our approach provides physical intuition and theoretical analysis. The behavior of intensity statistics (e.g. scintillation index or pdf of intensity) and of horizontal coherences is discussed. The probability distribution of intensity is shown to follow predominately a log-normal distribution in the limit that the number of propagating modes the distribution is definitely not log-normal, although it does have large intensity tail (as does the log-normal distribution) and therefore will also have acoustic intermittency (due to intensity outliers).

Title: Three Dimensional Visualization of Microstructures
Author(s): Marco Lanzagorta, Milo V. Kral, J. Edward Swan II, George Spanos, Rob Rosenberg and Eddy Kuo
E-Mail Address: swan@ait.nrl.navy.mil, rosenburg@ait.nrl.navy.mil
Citation: Proceedings of the IEEE Visualization 98, Research Triangle Park, NC: IEEE, 487-490.
Date: 18-23 October 1998
Report No.: AIT-98-017

Abstract

This case study describes a technique for the three-dimensional analysis of the internal microscopic structure ("microstructure") of materials. This technique consists of incrementally polishing through a thin layer of material, chemically etching the polished surface, applying reference marks, and performing optical or scanning electron microscopy on selected areas. The series of images are then processed employing AVS and other visualization software to obtain a 3D reconstruction of the material. We describe how we applied this technique to an alloy steel to study the morphology, connectivity, and distribution of cementite precipitates formed during thermal processing. The results showed microstructural features not previously identified with traditional 2D techniques.

Title: Underwater Imaging With a Moving Acoustic Lens
Author(s): Behzad Kamgar-Parsi, L. J. Rosenblum, E.O. Belcher
E-Mail Address: behzad@ait.nrl.navy.mil, rosenblum@ait.nrl.navy.mil
Citation: IEEE Transaction on Image Processing **7**, No. 1: 91-99.
Date: 1998
Report No.: AIT-98-040

Abstract

The acoustic lens is a high-resolution, forward-looking sonar for 3-D underwater imaging. In this paper we discuss processing the lens data for recreating and visualizing the scene. Acoustical imaging, compared to optical imaging, is sparse and low-resolution. To achieve higher resolution, we obtain a denser sample by mounting the lens on a moving platform and passing over the scene. This introduces the problem of data fusion from multiple overlapping views for scene formation, which we discuss. We also discuss the improvements in object reconstruction by combining data from several passes over an object. We present algorithms for pass registration and show that this process can be done with enough accuracy to improve the image and provide greater detail about the object. The results of in-water experiments show the degree to which size and shape can be obtained under (nearly) ideal conditions.

Title: Virtual Reality Reborn
Author(s): Lawrence J. Rosenblum; Guest Editor ,Grigore Burdea, Susumu Tachi
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: IEEE Computer Graphics and Applications **18**, no. 6: 21-23.
Date: November 1998
Report No.: AIT-98-029

This report has no abstract.

1997 PUBLICATIONS

AIT-97-002
Virtual Environments for Shipboard Firefighting Training; David L Tate, Linda Sibert and LCDR Tony King

AIT-97-004
An Anti-Aliasing Technique for Splatting; J. Edward Swan II, Klaus Mueller, Torsten Moller, Naeem Shareef, Roger Crawfis and Roni Yagel

AIT-97-005
A Non-divergent Estimation Algorithm in the Presence of Unknown Correlations; Simon J. Julier and Jeffrey K. Uhlmann

AIT-97-006
Generalized Non-Standard Finite Differences and Applications to Shock Wave Simulation; James B. Cole, Z. Jiang and K. Takayama

AIT-97-007
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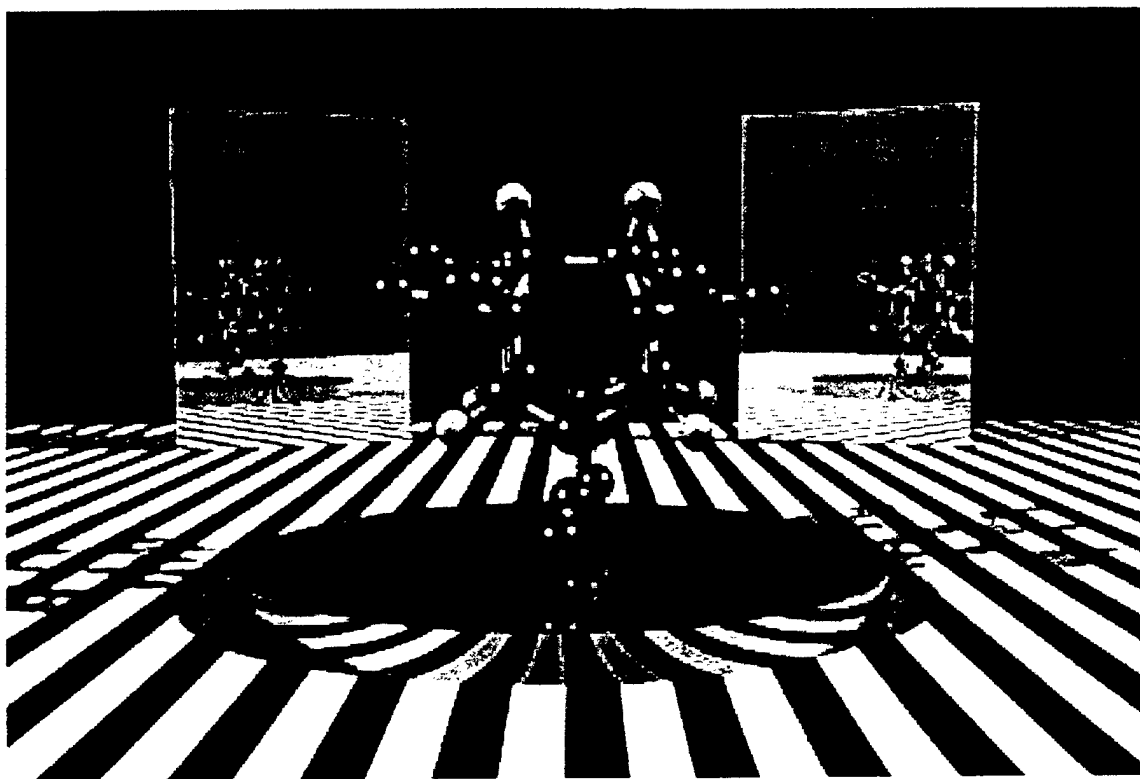
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Title: Asymptotic Rate of Bulk Data Transmission into High-speed Networks Under Optimal Schedules in Tandem-queue Model
Author(S): Daniel C. Lee
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Date: 19-22 July 1998
Report No.: CCS-98-001

Abstract
This paper discusses under a simple model the optimal schedules for transmitting finite amounts of bulk data from the premise of the data source into a communication network. The connection from source to destination is modeled by a single-server queue. The weighted sum of the expected queuing delays in the source premise and in the network is used as the performance measure, with more weight on the delay in the network. We focus on the average rate of data entry from the source premise into the network in the optimal schedule. As the size of the bulk increases, the average transmission rate of the corresponding schedule changes. This paper derives the asymptotic rate.

Title: High-Speed Networking Research at the Naval Research Laboratory
Author(s): Basil A. Decina
E-mail Address: decina@cmf.nrl.navy.mil
Citation: Presentation at Sprint's Third Annual ATM User's Conference, Chantilly, VA.
Date: 27-29 October 1998
Report No.: CCS-98-005

Abstract
The U.S. Naval Research Laboratory has pioneered the application and use of high-speed networking for over a decade. Early work lead to the adoption and promotion of Asynchronous Transfer Mode as a unifying protocol to support a wide variety of voice, video, imagery and data streams over the full range of transfer rates (from kbps to tens of Gbps). Research networks range from a SONET-based Washington-area network, ATDnet, to an ATM-based nationwide network, ACTS-ATM-Internetwork (AAI). Past efforts supporting fully-signaled end-to-end ATM services are transitioning to operational environments. Current and near-term efforts continue to push technology in a number of areas: Single-stream Segmentation-And-Reassembly (SAR) at 2.4 and 10 Gbps; Direct ATM interconnectivity at OC-48c and Wave Division Multiplexing (WDM); On-demand signaling of individual optical wavelengths (signaled WDM); Expanding authentication into user-to-network and network-to-network signaling; and Support of high-speed applications such as Progressive High-Definition Television (HDTU at 780p/60 and 1080p/60), distributed high-performance computing and distributed high-performance multimedia file systems.

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